SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1901.

GENERAL PHYSICS.

337. *Atwood's Machine.* **R. Malagoli.** (N. Cimento, 12. pp. 33–35, July, 1900. From Memorie della Società degli Spettroscopisti Italiani, vol. 28, 1899.)—The author investigates the history of Atwood's machine and its modern representatives. It was first proposed by Schober in 1751, and brought out by Atwood in 1784 at Cambridge. Of the modern improvements, that in which a continuous cord is used, so as to equalise the amount of cord on both sides of the pulley, is the most valuable. Even so, however, the error of the machine is not under 2 per cent. E. E. F.

338. *Lecture Experiments in Elasticity.* **W. S. Franklin.** (Phys. Rev. 11. pp. 75–78, Aug., 1900.)—The writer considers it extremely important that students should obtain a clear idea of the character of homogeneous strain, viz., three mutually perpendicular stretches, and that they should see the applicability of the notion of homogeneous strain to the small parts of a body non-homogeneously strained. Now as most students are not sufficiently acquainted with solid geometry to get a clear idea of the strain ellipsoid, the writer finds it useful to use the distortion of an elastic sheet as an illustration in two dimensions. An extremely thin sheet of rubber, slightly oiled with a non-mineral oil to make it semi-transparent, is stretched over a frame 15 to 20 cm. square. This state of the sheet is taken as the normal or unstrained state, and small circles (also a large circle) are marked on it. These small circles can be projected by a lantern. The sheet may now be stretched homogeneously, the sheet being fastened to the frame by a number of spring clips, and the circles are seen to be changed to similar and similarly placed ellipses. Stretching the sheet non-homogeneously the small circles are changed to dissimilar and dissimilarly placed ellipses; the large circle, however, differs from an ellipse. It is also instructive to show the distortion of square figures marked upon the sheet.

In the discussion of shearing strain the writer uses a large square hinged frame, over which muslin cloth is stretched, the threads of the cloth being parallel to the sides of the frame. The reduction of a shearing strain to two diagonal stretches mutually perpendicular is most clearly shown by drawing a large circle on the muslin. This circle is changed by the distortion to an ellipse with its axes diagonal to the frame. In the discussion of strains and stresses in a twisted cylinder the writer uses a large tin cylinder covered with muslin, which is fastened to the cylinder at one end and to a loose circular disc at the other. Squares and circles marked upon the muslin show very clearly the strains produced when the circular head is slightly turned.

At the end of the paper the writer gives an outline of what he considers the most satisfactory elementary development of stress-strain relations, which he thinks are not satisfactorily treated in any of the text-books. E. C. R.

339. *Torsional Rigidity of Wires under Longitudinal Stress.* **J. R. Benton.** (Ann. d. Physik, 3. 3. pp. 471–491, Nov., 1900.)—The torsional rigidities of wires of different metals under longitudinal stress are here experimentally determined, the lateral contraction being measured and the rigidity moduli being calculated on the reduced sections. The metals used are steel, iron, copper, nickel, brass, nickeline, German silver, red brass, and bronze. In all the metals except nickel the rigidity modulus diminishes with increased load. The rigidity modulus is represented by the formula—

$$m = \alpha + \beta P + \gamma P^2,$$

where P is the stretching force and α, β and γ are constants. The values of β and γ are given in tables in the paper, and these vary with the diameter of the wire used, presumably owing to the influence which the outer surface layers of the wire exert on the torsional rigidity. As the diameters of the wires are increased, β and γ approach more nearly to constancy.

The experimental method used is the vibrational one, and a special optical micrometer employing Newton's rings is used to measure the lateral contraction. J. B. H.

340. *Rates of a Rocking Watch.* **C. Barus.** (Phil. Mag. 50. pp. 595–604, Dec., 1900.)—A watch mounted in a hard wood ring is suspended on a knife edge placed parallel to the axis of the watch and so that the natural period of the pendulum, thus formed, is approximately the same as the period of the balance wheel. The watch when left to itself rocks permanently to and fro through a considerable angle and lends itself beautifully to the study of the interference of two nearly synchronous vibrations. The problem is complicated, however, by the vibrations of the pendulum not being simple harmonic while those of the balance wheel are.

A comparison of the rate of the watch while thus suspended with that of a good chronometer shows that the balance wheel in these conditions has two distinct periods, one longer than its natural period and the other shorter, the period changing from the one to the other after the lapse of certain intervals of time. The interval during which the short period lasts is longer than that during which the long period lasts, and consequently the rate at which the watch gains time in the former is less than the rate at which it loses in the latter.

By adding little weights at the bottom of the ring the moment of inertia of the pendulum is altered, and these rates are correspondingly altered, the rate at which the watch loses time on the long period increasing continuously with increased moment of inertia, while the rate at which it gains time on the short period diminishes correspondingly.

The author applies the theory of a system of two degrees of freedom as given by Rayleigh in his treatise on Sound. He also shows how these experiments illustrate Rayleigh's theory of anomalous dispersion, and finally he considers the application of the apparatus as a differential gravity meter, the rate at which the watch loses on the long period being a sufficiently sensitive measure of *g*. J. B. H.

341. *Nature and Velocity of Gravitation.* **R. A. Fessenden.** (Science, 12. pp. 740–745, Nov. 16, 1900.)—The present article supplements the work dealt with in Abstracts Nos. 1233, 1234, 1235, 1277, 1278, and 1279 (1900), and Abstract No. 20 (1901). Taking Boys' value for the gravitational attraction of two masses, the author finds 10^{-48} erg as the gravitational energy of one of J. J. Thomson's corpuscles. From this and the electrostatic stress the volume elasticity [of the ether] is made of the order 10^{73}. The density and rigidity of the ether have previously been calculated to be 0·66 and 6×10^{20} respectively. Whence the velocity of the compressional or gravitational wave is calculated to be approximately 5×10^{36} cm. per second. E. H. B.

342. *Conductivity of Copper containing Phosphorus and Arsenic.* **A. Rietzsch.** (Ann. d. Physik, 3. 3. pp. 403-427, Nov., 1900.)—An extension of Matthiessen and Holzmann's work on the great decrease of conductivity of copper by addition of phosphorus or arsenic. The thermal and electric conductivities (K_T, K_E) of copper bars and plates containing varying quantities of the above substances are measured. K_T for the rods is found by Wiedemann and Franz's apparatus and method; K_T for the plates is measured by Voigt's method. A rectangular plate is made up of two different metals joined along the diagonal; it is painted with a solution of 0·35 gm. elaidic acid in 5 c.c. absolute alcohol. The short end of the plate is then placed on a copper block at 100° and removed when the melting of the coating has reached a certain point on the diagonal. The relative conductivities are then as the tangents of the angles between the isothermals and the diagonal. K_E is measured by a null method. Tables of results are given. Four curves show the intimate relation between K_T and K_E. Values for pure copper being taken as 100, the curves of variation of K_E and K_T with addition of P or As are almost coincident, that for K_E being slightly above that for K_T. Also, the correction of the Wiedemann-Franz law of proportionality of K_T and K_E is for copper containing phosphorus and for arsenical copper in the opposite direction to that found by Jaeger and Diesselhorst for mixtures of purely metallic substances. G. E. A.

343. *Lambert's Theories.* **C. Chistoni.** (N. Cimento, 12. p. 36, July, 1900. Atti della Società dei Naturalisti e Matematici di Modena, serie 11, vol. 1, pp. 66–88.)—In this work the author attempts to render more precise Lambert's conceptions and definitions concerning the reflection of light and heat, and the cooling of bodies. In connection with the latter, he discusses especially Newton's law. E. E. F.

344. *Atmospheric Radiation.* **F. W. Very.** (U.S. Weather Bureau, Bull. G., No. 221, pp. 5-134, 1900.)—The investigation was commenced in 1892 at Alleghany Observatory and continued later at Providence, R.I. The radiation was measured with a bolometer (Langley's early type) consisting of thin strips of blackened platinum, arranged in two series. The ideal aimed at in the experiments was to obtain a concave surface of silver (silvered copper) at constant temperature, having the bolometer at its centre of curvature completely filling the circular openings in the multiple screens of polished metal; volumes of hot and cold air were rapidly substituted between the bolometer and the outer screen. As the radiating power of a gas is very low in comparison with the emissive power of a solid, the mirror was coated with lampblack which, it was supposed, would retain substantially the temperature of its metallic backing. As the method did not prove satisfactory, the bolometer was pointed to a cold screen entirely separated from the hot air which issued from a flue. Finally the experiments on the radiations from air, carbon dioxide, aqueous vapour, and other substances at reduced pressures, and from multiple flames, were conducted in a closed chamber fitted with a rock-salt window; this apparatus tended to leak when heated so that high temperatures could not be applied. The paper describes the standardising of the apparatus and the methods employed, dwells on Reid's bolometer formula, and discusses the results obtained with especial reference to Tyndall, Langley (in whose work the author assisted), and Paschen.

Gaseous water produces a very potent influence of its own; but the absorption increases decidedly with incipient condensation. The relation of aqueous absorption and radiation is complex. The radiations of clouds, the sea, and of moist earth and of vegetation, do not much differ from the radiant emission of a solid black body, whose spectral energy has, at terrestrial temperatures, its maximum in the immediate vicinity of the chief aqueous absorption bands. The position of this maximum absorption varies with the amount of water in the atmosphere and with its physical state; and the position of the maximum of the unabsorbed energy curve also varies with the temperature of the radiating body and of the surface to which it radiates. A highly absorbent gas, which is also a powerful radiator in thin layers, may become a poor radiator with greater depths. The small masses of the mixed gases and vapours of the laboratory radiate chiefly by their most highly radiative molecules, the others transferring their heat to these kinetically; whilst in the large masses of the atmosphere the feebly radiative molecules act as the chief radiators, except in their outer layers. The radiation proceeds, in deeper layers, slowly from one portion of air to a colder neighbouring portion. There seems to be a certain analogy between dry air and rock-salt; both emit waves of great length, and are poor radiators in small masses, and better ones in thick layers. The radiation of homogeneous air of moderate depth appears to depend, for a given temperature, merely on the product of density and depth; but the absorption of a given mass of aqueous vapour is smaller when distributed through a large volume of air than when concentrated. As an absorbent of terrestrial radiations, water vapour is much more efficient than any other constituent of the atmosphere; but as radiators, when in large masses, the constituents do not differ very widely, and the carbon dioxide and the gases may also be the chief radiators, according to the temperature and the depth of the layers.

The atmosphere produces a selective scattering, particularly of the short waves; the light is further diffracted by minute ice crystals and reflected more indiscriminately by coarse dust particles; but the rays, which are taken out of the beam in this way, do not alter the temperature of the air, and a large portion of them reach the earth. It is different with the line and band absorption, because that energy is transformed into energy of molecular or atomic movement, and remains in the air as an increase either of its sensible or its latent heat. As the composition of the atmosphere is continuously changed by emanations from the earth and its inhabitants, the atmospheric thermal energy is increased in this manner. This increase of temperature is lost again by radiation which, being obstructed downward by the greater density and humidity of the lower strata, is mainly diverted outward. In a measure, the emission of the air resembles its absorption, but it is confined to the longer waves; the radiations of oxygen, nitrogen, argon, and krypton at low temperatures remain to be explored. As regards the solar spectrum the absorbent action of carbon dioxide and of the gases is almost invariable; but the absorption bands of aqueous vapour and the selective scattering of short waves are much stronger in summer than in winter. For this reason the direct winter sunrays appear more powerful than the summer rays; the rays are less potent in the tropical zone than in the temperate zones, and less at sea-level than on mountains. The heat entrapped through the differential transmission of solar and terrestrial radiations is mainly stored in the lower strata. The gradual accumulation of moisture in the higher strata during the summer gives us the warm autumns; the opposite reason explains the cold spring season. Temperatures lower than — 78° C. possibly cannot occur on the earth on account of the almost total absorption of all radiations beyond 13 μ. Cooling of moist air by radiation cannot be responsible for large rainfalls, as, owing to the peculiar absorption of its own rays, the radiation can only proceed through a thin surface layer which will soon become saturated by the cooling. In the higher atmospheric strata cooling by radiation plays an important part. H. B.

345. *Formation of Hailstones.* **A. Artom.** (Elettricità, Milan, 19. pp. 690–692, Nov. 8, 1900.)—The author puts forward a theory of the formation of hailstones, based on the rotation of an insulator in a partially insulating fluid medium, when subjected to an electric field. In hail-forming clouds the requisite conditions for such rotation obtain; the highly insulating frozen particles are in air charged with very fine drops of water, this forming a medium with relatively low insulating properties; an electric field then determines a rotation of the frozen particles, which thereby come into contact with and congeal the surrounding liquid drops. The author claims that the stratified formation of hailstones tends to confirm this theory. G. H. B.

346. *Hail and Hail-dispersing Cannonades.* **W. Weiler.** (Elekt. Runds. 18. pp. 33–34, Nov. 15, 1900.)—The author draws attention to the renewal of Volta's hail theory by Marangoni, and to the thunderstorm theory of A. Krebs. The former accentuates the low elevation of the hail clouds; the firing would shake these clouds, dispersing the water globules, and would prevent their up-and-down motion and their freezing. The latter ascribes the formation of thunderstorms to whirls which the air column, discharged from the gun, would destroy. H. B.

347. *Action of Hail-dispersing Guns.* **G. Gastine** and **V. Vermorel.** (Comptes Rendus, 131. pp. 766–768, Nov. 5, 1900.)—In order to study the air column, issuing from the gun, the authors constructed targets of iron wires, 2 mm. thick, 10 cm. apart, fixed in a wooden frame, 5 m. sq., and covered with paper. At a range of 60 or 80 m. a ring was torn out of the target, 2 m. in diameter and 20 cm. in width; a similar ring was obtained with a smaller gun at 6 m. range. The effect is due to a ring-shaped whirl which is deflected by the ground, trees (which it strips of leaves), and houses, even if they are some distance from its path. It is therefore difficult to hit the target, and the whirl projectile may be deflected by a right angle after striking an obstacle. It

travels slowly with a hissing noise. Lumière Brothers have taken photographs with a kinematograph at intervals of $\frac{1}{17}$ second, with good results; and Grandvoinnet has photographed a whirl 3 m. in diameter. H. B.

348. *Rock Temperature at Sydney Harbour Colliery.* **J. L. C. Rae, E. F. Pittman,** and **T. W. E. David.** (Roy. Soc. N. S. Wales, Journ. and Proc. 33. pp. 207–223, 1900.)—The observations were made in 1899, in accordance with the recommendations of the Brit. Assoc. Committee on Underground Temperature, and partly with their instruments (slow-action and maximum thermometers), at the Birthday Shaft, Balmain, Sydney, which was already 600 feet deep, and this has since been carried down to a depth of 1,449 feet, and will be sunk to 3,000 feet. The thermometers were placed at intervals of 50 feet in horizontal holes, from 3 to 5 feet deep, which were left open for from 34 to 84 hours after insertion of the thermometers; strings were attached to the thermometers, and their copper cases were plugged with greasy cotton waste and clay. Withdrawal followed after a minimum period of 37 hours. So far an average rise of temperature of 1° Fahr. per 90·7 feet has been observed; the curve, however, is irregular. The paper records in detail the strata, chiefly sandstones and shales, often less than a foot in thickness, and refers to the water circulating in the strata. H. B.

349. *Magnetised Chronometers and Terrestrial Magnetism.* **A. Cornu.** (Comptes Rendus, 131. pp. 859–865, Nov. 26, 1900.)—Since the steel parts of an accidentally magnetised watch do not come into actual contact, there is no reason why such a watch, if it is not altogether stopped, should afterwards stop occasionally, provided that all magnetic dust has been removed. The author had a very badly magnetised demi-chronometer thoroughly cleaned, but not demagnetised. When placed horizontally in different meridians it continued to go regularly for years, the deviations from uniform movement (not more than a few tenths of a second per day) depending upon the azimuth. The observations were confirmed by compensating the magnetism of the watch; the magnetic orientation then had no more influence. The movement follows a sinusoidal law, just as a watch whose balance is not in perfect equilibrium behaves, according to Phillips, under the influence of gravity when placed in a vertical position. Chronometers on board ship, and particularly on iron vessels, are, therefore, affected by the variation in the terrestrial magnetic field, resulting from changes in the course steered and other causes, because no balance will be entirely free of magnetism. Corrections are, however, possible. The shielding action of iron boxes should be further studied both in observatories and on board ship. H. B.

350. *Cause of Polar Lights.* **S. Arrhenius.** (Phys. Zeitschr. 2. pp. 81–87, Nov. 10; and 97–105, Nov. 17, 1900; from the Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, p. 545, 1900.)—This is really a cosmical paper. In order to explain the apparent repulsion of comets' tails by the sun, the author starts from the hypothesis, first advanced by Euler, clearly shaped by Maxwell, and quite recently established experimentally, it is said, by Lebedejew, that the light waves exercise a pressure on the surface which they illuminate. That pressure would be much stronger on the sun's surface than near the earth, and would, on the sun, for a substance opaque to light rays, be able to counterbalance the influence of gravity on a cubical particle having an edge of 10^{-4} cm. A spherule of density 1 and diameter 1·5 μ (or of diameter 0·8 μ and density 5) would no longer be attracted by the sun;

a smaller particle would be repelled. From the curvatures of two selected comet tails, Bredichin has calculated that this repellant action of the sun must be respectively 18·5 and 1·5 times the force of gravity; if we assume that the comets consist of hydrocarbons of density 0·8, the spherules forming those tails could not be larger than 0·1 and 1·25 μ respectively. These figures are not absurdly small, as there are organised bacilli of smaller size. When a comet approaches the sun a boiling process goes on in the advance portions; the gases may be condensed to drops or soot particles, and form the advance tails occasionally observed. Cosmical particles may come from the faculæ and produce the rays of the corona. Most of this matter would fall back into the sun, some particles are repelled into space. The electric discharges occurring on the sun produce kathode and Röntgen rays, which ionise the particles; the negatively charged particles, which serve as condensation nuclei (C. T. R. Wilson), travel and meet celestial bodies, electrify them, are again repelled, and form a cosmical shadow behind these bodies which, owing to the deflection of the particles, will be wider than the optical shadow. The day-side of the earth is exposed to such a rain of negatively charged particles. They are arrested in the highest strata of our atmosphere, at an altitude of perhaps 200 km., and produce kathode rays when discharged by ultra-violet light; the auroræ are kathode-ray phenomena. They are not visible in those high altitudes, because the air is too rarefied, and they do not produce more than a luminous glow (with the auroral line) in the equatorial belt, which receives most particles, because there the magnetic lines of force lie parallel to the earth's surface. Near the poles, where the magnetic lines are vertical, the kathode rays can penetrate more deeply into the atmosphere. This hypothesis is in accordance with the various periods of auroral frequency: the sun-spot period, equatorial maxima and solstital minima, synodical sun period, tropical moon, and diurnal earth period. The latter particularly are almost obscured by the sunshine and moonshine periods; but the real frequency maximum of auroræ seems to fall in the early afternoon (Gyllenskiöld). This hypothesis also explains the zodiacal light; the disturbances, annual, diurnal, and auroral, of the magnetic elements; the heterogeneous character of certain meteorites; and, further, the glow of stellar nebulæ. What we see glow in the probably cold nebulæ is the outer least dense layers, in which the cosmical particles are caught and discharged; we perceive only the hydrogen and helium lines because the denser substances are in the inner strata. H. B.

351. *Danish Polar Light Expedition to Iceland*, 1899–1900. **F. Neesen.** (Deutsch. Phys. Gesell., Verh. 2. 15. pp. 218–220, 1900.)—A preliminary account of this expedition, in which A. Paulsen, La Cour, and Moltke took part. The author exhibited the water colour and oil paintings which Moltke had made on the spot after his own pencil sketches. One aurora shows a multiple arc with rays, the others strange luminous waves. In one instance a wheel with doubly curved spokes was observed; there was no rotation about the centre of the wheel, though the white or greenish-white light was in constant motion. The spectrum photographs mark lines and a continuous spectrum between 407 and 470 $\mu\mu$; the continuous spectrum is probably due to moonlight; the lines agree, according to Scheiner, with the kathode lines of nitrogen as to position and intensity. Observations of atmospheric electricity were taken on fifty-three days, but were successful on eleven days only, owing to snowstorms; the minimum air potential occurred at about three or four o'clock in the morning, the maximum about noon. The magnetic needle was but little disturbed, and was never deflected by more than 8°, whilst deflections of 10° had been

observed in East Greenland; but the quiet arc was at right angles to the meridian, and some of the auroræ were at high altitudes, up to 400 km. A positive current was apparently flowing from west to east. H. B.

352. *Total Solar Eclipse, May 28, 1900. and Research during Eclipses.* **R. Gautier, A. Riggenbach,** and **A. Wolfer.** (Archives des Sciences, 10. pp. 193–209, Sept.; and 329–344, Oct., 1900.)—The first part of this paper is a report of the instrumental equipment and results obtained by the expedition, consisting of the above astronomers, to Ménerville, in Algeria.

The second part of the paper gives a summation of the various points on which it would be advisable to direct inquiry. The main problems are as follows:—

(1) *Corona.* (*a*) Relation of streamers to prominences; (*b*) Position with regard to sun's axis; (*c*) Variation of form with time, long and short period; (*d*) Rotation; (*e*) Spectrum; (*f*) Polariscopic, photometric, and calorific measurements.

(2) *Reversing Layer.*

(3) *Prominences.* Varying forms of same prominence as photographed or seen in lines of different refrangibility.

(4) *Intramercurial planets.* C. P. B.

353. *Suggested Explanation of the Solar Corona.* **W. Huggins.** (Astrophys. Journ. 12. pp. 279–280, Nov., 1900.)—This note is in answer to a former article by Scheiner [see Abstract No. 2400 (1900)], and gives extracts from the Bakerian Lecture, 1885, showing that the *direct solar radiation* origin of the corona was then considered probable by the writer (Huggins). Reference is also made to Huggins' presidential address to the Brit. Assoc. 1891, p. 1, in which he concludes that the corona is caused in a similar manner to the tails of comets, that is by matter going from the sun under electrical forces. The new results of Langley and Newall are yet under discussion, but are likely to supply important additional information. C. P. B.

354. *Observation of Corona in Daylight.* **R. W. Wood.** (Astrophys. Journ. 12. pp. 281–286, Nov., 1900.)—The author describes a series of experiments undertaken at the Lick Observatory to try the possibility of detecting the corona during daylight by methods based on the eclipse observation that some 15 or 20 per cent. of the coronal light is polarised. The results were so far negative, but several suggestions are given for future work. C. P. B.

355. *Distribution of Minor Planets.* **de Freycinet.** (Comptes Rendus, 131. pp. 815–821, Nov. 19, 1900.)—The article is a somewhat longer and more complete discussion of the question of the distribution of the zone of asteroids than that first communicated [Abstract No. 1628 (1900)]. On the assumption that these small bodies are the product of disruption of a former ring of matter revolving round the central body, he calculated the mean eccentricities of the several rings into which it might be expected to divide. On examination of the elements of the 428 of the present known planets, it has been possible to divide them into eight groups, the members of each group having similar eccentricity and inclination of orbit. The numbers of separate bodies in each zone vary greatly—from 1 to 170. The mean thickness of the rings is 0·278, the radius of the earth's orbit being taken as unit—the individual rings varying from 0·22 to 0·36. In each ring the mean eccentricity of the members situated in the inner or inferior half is greater than that of the members

occupying the superior or outer half; and comparing two rings, it is found that the mean eccentricity of the planets in the inferior part of the outer ring is greater than that of those occupying the superior part of the inner ring. In one ring—the fifth—consisting of 69 planets, the mean eccentricities of the two halves are identical, and it will be interesting to examine the places occupied by asteroids discovered in the future as to their effect on the constants of this region of the minor planetary swarm. C. P. B.

356. *Escape of Gases from Planetary Atmospheres.* **G. Johnstone Stoney.** (Roy. Soc., Proc. 67. pp. 286–291, Nov. 14, 1900; also Astrophys. Journ. 12. pp. 201–207, Oct., 1900.)—This problem has been mainly investigated by three writers—Stoney, Cook, and Bryan. Stoney has previously considered Cook's view of the question [see Abstract No. 1988 (1900)], and in the present paper the inquiry is dealt with in the manner put forward by Bryan. He brings forward several conditions which would probably render unavailable the supposition of partition of energy among the atmospheric molecules. The chief of these are (*a*) the fact that a body may have two kinds of temperature, radiation and conduction; (*b*) the influence of the field of force due to the earth, &c., in which the molecules have to move; (*c*) the continual variations introduced by the many disturbances produced in the atmosphere. He, on this reasoning, concludes that the restriction of the Boltzmann-Maxwell law within our atmosphere is a mistake, and therefore that the inferences from it are not a real interpretation of the facts of nature. C. P. B.

REFERENCES.

357. *Gerschun's Proposed Method for the Determination of the Density of the Earth.* **A. Sella.** (Archives des Sciences, 10. pp. 322–328, Oct., 1900.)—The author deals mathematically with this method [see Abstract No. 442 (1900)] with a view to testing its feasibility. E. H. B.

358. *Meteorological Observations in Geneva,* 1899. **R. Gautier.** (Archives des Sciences, 10. pp. 345–363, Oct.; 467–484, Nov.; and 539–556, Dec., 1900.)

LIGHT.

359. *Colour Produced by Simultaneous Contrast.* **G. J. Burch.** (Roy. Soc., Proc. 67. pp. 226–228, Nov. 14, 1900.)—The author here describes a new method of studying the apparent changes produced in the colours of a spectrum when the colour of the background is changed. An ordinary stereoscope is used, one field having a blue glass background and the other one of red glass. In front of the aperture by which light is usually admitted when viewing opaque pictures two slits are placed, and a grating is placed in each eyepiece. The first order spectrum of each slit appears near the centre of the corresponding field, and the slits are arranged so that on looking through the stereoscope the two spectra are seen side by side. To prevent the direct mixing of the colours of the spectra with those of the backgrounds two black patches are put on each of the backgrounds, so situated as to correspond exactly in position with the spectra.

On looking through the spectroscope two spectra are seen side by side on a field, the colour of which continually oscillates from red through purplish grey to blue. The spectrum connected with the red glass shows little or no red, but a splendid green and an equally splendid violet; while that belonging to the blue glass has the red well developed, the green pale and dingy, and the blue almost absent. By varying the coloured glasses or superposing others on them different results are obtained.

Hering's contention, that contrast phenomena originate in the eye rather than in the mind, is substantiated, but the complementary colour to red is shown to consist not of one simple colour-sensation but of two at least, namely, green and violet, and in the author's case also blue. A magenta ground is complementary to a spectral green, but on adding a yellow glass to the magenta one to cut out the violet rays the violet reappears in the complementary spectrum, while, if a blue glass is added instead, the violet vanishes and red stands out brightly in the spectrum. The colour which has green for its complementary is thus shown not to be spectroscopically simple.

J. B. H.

360. *Transparency of the Atmosphere.* **C. Chistoni.** (N. Cimento, 12. pp. 35–36, July, 1900. Atti della Società dei Naturalisti e Matematici di Modena, serie 3, vol. 16. pp. 165–187.)—The author reduces to modern terms and methods the researches of Bouguer on atmospheric absorption, and summarises the work done in the same connection by Pouillet, Violle, Maurer, Angot, Forbes, Crova, and Radau. E. E. F.

361. *Acetylene, particularly as a Photometric Standard.* **E. L. Nichols.** (Frank. Inst., Journ. 150. pp. 356–387, Nov., 1900.)—A description of some properties of the acetylene flame regarded as a laboratory adjunct, and, to some extent, a compilation of results of some previous investigations. It is found that the luminosity of acetylene depends very much on the age of the gas. A gasometer filled with acetylene was found in five months to contain about 25 per cent. of acetylene, and the degenerated gas had only 6 per cent. of the illuminating power of freshly made acetylene. Also the illuminating power of acetylene made by dropping small lumps of calcium carbide into water is 20 per cent. greater than that of acetylene prepared by dropping water on the carbide. A gas pressure regulator and a spectro-photometer used in the investigations are described, and the paper further treats of the illuminating power of mixtures of C_2H_2 and H_2, of the stability of the flame, its intensity in different directions and with different burners, its power as compared with other illuminants and its value as a photometric standard.

G. E. A.

362. *Thermodynamics and the Magneto-Optical Faraday Effect.* **M. Planck.** (Deutsch. Phys. Gesell., Verh. 2. 14. pp. 206–210, 1900.)—In this paper the author disposes of the seeming contradiction of the laws of thermodynamics in the problem presented by Wien first in 1894 and again in his Paris address on the theoretical laws of radiation.

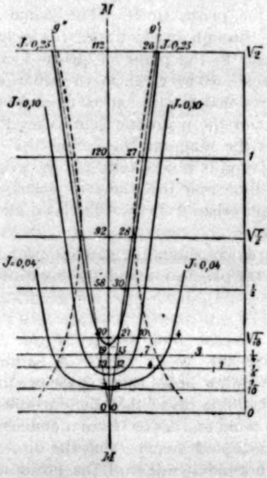
The seeming paradox is as follows: Suppose two similar black elements at the same temperature to have two Nichol prisms placed between them, the one rotated 45° relatively to the other, and suppose that between the prisms a magnetic field exists, which rotates the plane of polarisation by 45°. The radiation from the element A towards the element B passes first through prism 1 and is polarised. It then passes through the magnetic field, and the plane of polarisation is rotated through 45°, so that on reaching prism 2 it all passes through the prism to B. The radiation from B towards A, however, after passing through prism 2 and the magnetic field, is polarised in a plane perpendicular to the plane of prism 1, and no radiation passes through. It thus appears B receives more radiation from A than A does from B. Planck shows that the radiation from B to A, supposed parallel after passing prism 2 and the magnetic field, is totally reflected by prism 1; it then again traverses the magnetic field, and the plane of polarisation is rotated so that the radiation is totally reflected by prism 2; it then traverses the field for the third time, and the plane of polarisation is rotated so that the beam passes through prism 1 to A. The two elements thus receive the same amount of radiation.

The author afterwards considers the general problem in which the angle between the planes of the prisms is ϵ and the rotation by the magnetic field is α.

J. B. H.

363. *The Kathode Stream and Röntgen Light.* **W. Rollins.** (Amer. Journ. Sci. 10. pp. 382–391, Nov., 1900.)—A summary and discussion of current opinions. The author holds that a space of strained ether is necessary for the production of kathode rays; that the particles of the kathode stream repel one another and come to a focus (from a concave kathode) beyond the place required by the accepted theory; that the direction of the particles in the kathode stream is not independent of the position of the anode at high vacua; that the kathode stream particles are not always of the same size, moving with the same speed and carrying the same charge, for from a mercury kathode they are heavier and fail to set up Röntgen rays, producing ordinary light instead; that the kathode stream is due to gas amalgamated with the kathode and stops when this is exhausted; that ultra-violet light impinging on a kathode will not cause a kathode stream; that the radiations from a radio-active "kathode" in a kathode tube cause radiations differing from Röntgen rays, being diffused in the tissues of the hand like ordinary light. The theory of indivisible atoms is not now admissible; no more is the idea that the particles in the kathode stream are ultimate components, for their spectrum is too familiar, too complex, and not new. Trowbridge obtained the spectrum of water vapour, A discussion of opinions follows as to the Röntgen rays. The author holds these to be short ether waves due to impact and heating of the impinging particles, which become radiant centres and thus cool down. If the area struck by the impinging particles is kept very cold there is less Röntgen radiation. The transparency of aluminium to Röntgen radiation is inconsistent with the ordinary solid atom theory, but is consistent with a theory that aluminium atoms and kathode-stream sub-atoms are made up of ultimate atoms proportional in number to the atomic weight, and themselves identical for all elements, and that there is ether between these. A platinum target faced with aluminium is not an efficient reflector of Röntgen rays, as on the transparency theory it ought to be, and it would appear that the aluminium atom is a more open structure than a platinum atom. A. D.

364. *Diffraction of Röntgen Rays.* **A. Sommerfeld.** (Phys. Zeitschr. 2. pp. 55–60, Oct. 27, 1900.)—Mathematical study of the theory of abrupt impulses, revised, corrected, and continued [*cf.* Abstract No. 1798 (1900)]. It is ascertained that the method of Huyghens' principle, in the sense of Kirchhoff's formulation of the same, is applicable, as a means of getting sufficiently approximate results, when the breadth of the impulse is sufficiently small. The accompanying diagram summarises the conclusions. The slit is a triangular one, exaggerated in its dimensions. The scale at the side shows what proportion the corresponding breadth of the slit bears to $\sqrt{8\lambda x}$, where x is the distance from the slit, and λ is the breadth of the impulse. The figures down the mid-line show the values of the intensity, which rises to a maximum at a breadth equal to $\sqrt{8\lambda x}$, and then falls off (the numerals being given a hundredfold value, 120 for 1·20, and so on). The curves $J = 0·04$, $= 0·10$, and $= 0·25$ show lines of equal intensities. The dotted lines show where the intensity is equal to one-fourth of what it is opposite the centre of the slit, and it is seen that the narrower the slit the more uniform is the intensity on the screen, and the farther does the proportional brightness



extend beyond the geometrical shadow. If we take the line $J = 0{\cdot}25$ as marking the limit of what can be photographed, and also take the substantial widening as taking place at the same level, we find that this level corresponds to a slit-breadth of $\sqrt{1/10} \, . \, \sqrt{8\lambda x}$. In Haga and Wind's experiments this limit was reached at a slit-breadth of $9 \, . \, 10^{-3}$ mm. at a distance of 75 cm., whence $\lambda = 1{\cdot}3 \times 10^{-7}$ mm., a value much smaller than that given in the previous paper, but preferable. It approximates to molecular dimensions, which accounts for many of the peculiarities of Röntgen rays. Some of Haga and Wind's results are to be accounted for by the Röntgen rays presenting an admixture of impulses of different breadths. The disturbances here studied form a limiting case, at the opposite extreme to the regular oscillations studied in Optics. A. D.

365. *Alternating Currents and Radiography.* **P. Villard.** (Archives d'Él. Médicale, 8. pp. 502–509, Oct., 1900.)—Description of apparatus. A transformer is described converting alternating current at 110 volts and 7 or 8 amperes to 50,000 volts effective, 70,000 maximum. In the secondary circuit there is a pair or a number of pairs of condensers, to limit the quantity in the secondary circuit to an amount determined by the capacity of the condensers. Across the secondary circuit, beyond the condensers, a Villard electric valve (Archiv. d'Électr. Méd., May, 1899, p. 181) which allows discharges only in one direction through itself, and therefore only allows the opposite discharge to affect the Crookes tube, which thus is traversed by discharges in one direction only. The voltage in the Crookes tube is also increased by the use of this electric valve. Arrangements are also described for dividing and distributing the secondary current, as, for example, for stereoscopic radiography with two Crookes tubes alternately illuminated. Crookes tubes work very smoothly with the arrangements described, as if the regular alternating action of the transformer and condensers were beneficial. On the whole the results resemble those obtained by means of a static machine, and the effect on a photographic plate may be still further improved by laying a very thin metallic film on the plate so as to cut off the less penetrating radiations. A. D.

366. *Phosphorescent Glow in Gases.* **J. B. B. Burke.** (Electrician, 45. p. 936, Oct. 12, 1900 (Abstract). Paper read before the Brit. Assoc., 1900.)—Phosphorescent glow produced by electrodeless discharge can diffuse in gases, and if the diffusion take place through a narrow brass tube put to earth, so that no ionised particles can accompany it, the phosphorescent glow which has traversed this brass tube is relatively very persistent, and it is electrically conductive. A. D.

REFERENCES.

367. *Blue Colour of the Sky.* **N. E. Dorsey.** (Monthly Weather Rev. 28. pp. 382–389, Sept., 1900.)—A historical account of the theories as to the colour and polarisation of the light from the sky, concluding with a bibliography of works on the subject. J. J. S.

368. *Iris Diaphragm in Radioscopy.* **A. Béclère.** (Archiv. d'Él. Médicale, 8. pp. 510–519, Oct., 1900.)—Description of apparatus and discussion of the advantages obtained in medical work by diminishing the effect of secondary radiations and adjusting the area of the field of view so as to obtain the maximum definition consistent with adequate illumination of the field. A. D.

HEAT.

369. *Underground Temperature at Oxford.* **A. A. Rambaut.** (Roy. Soc., Phil. Trans. 195. pp. 235–258, Nov. 22, 1900 ; Abstract in Roy. Soc., Proc. 67. pp. 218–222, Oct. 31, 1900.)—The monthly means of the readings at noon for the year 1899 of five platinum resistance thermometers, buried one below the other in undisturbed gravel at depths 119½, 68½, 42½, 18, 6½ inches respectively, and of a standard mercury thermometer in a Stevenson screen were expressed by Fourier series in which a yearly and a half-yearly wave were alone taken into account. The respective amplitudes due to the annual wave were 5·102°, 8·305°, 10·581°, 13·305°, 15·411°, 12·878° Fahrenheit, and their retardations in phase were 202·71°, 230·18°, 243·48°, 256·40°, 264·39°, 262·77° ; comparison of the first four amplitudes in pairs gives numbers between 0·1191 and 0·1222 for the value of $\sqrt{(\pi/\kappa)}$, where κ is the diffusivity of gravel, and lengths are measured in Paris inches, and comparison of the first four retardations gives numbers between 0·1141 and 0·1202. The mean of all is 0·1189, which is the same as that (0·1187) obtained from the semi-annual wave, though in the latter case the individual numbers lie between 0·0949 and 0·1445 : and these four thermometers agree in giving 15·65° and 2·92° as the respective amplitudes of the annual and semi-annual waves at the surface of the gravel. Discrepancies between theory and the observations are not wanting, but these are not larger than may be *a priori* expected. R. E. B.

370. *Radiation of Black Bodies.* **O. Lummer** and **E. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 2. 12*a*. pp. 163–180, 1900. In substance this paper was communicated to the Physical Section of the Naturforscherversammlung in Aachen on September 18, 1900.)—The authors have extended their observations on the distribution of energy in the spectrum to wave-lengths between 12 μ and 18 μ, and temperatures between 85° and 1800° abs., confirming their previous conclusion that Wien's law is invalid. Discrepancies occur between the observed values and the values calculated from this law, which amount to one-half of the observed values at high temperatures. The differences are exhibited by plotting the observed and calculated isochromatic curves. The observations completely verified Stefan's law, and the equations $\lambda_m T = \text{const.}$, and $E_m T^{-5} = \text{const.}$ (E_m being the maximum energy), which are derivable from the general equation of Lummer and Jahnke [see Abstract No. 71 (1901)], viz. :—

$$E = CT^{5-\mu}\lambda^{-\mu}\, e^{\frac{-c}{(\lambda T)^{\nu}}}$$

Under which appear as special cases the equations of Wien ($\mu = 5$, $\nu = 1$), Thiesen ($\mu = 4{\cdot}5$, $\nu = 1$), and Rayleigh ($\mu = 4$, $\nu = 1$). The general equation with the values $\mu = 4$, $\nu = 1{\cdot}3$ leads to isochromatic curves in satisfactory agreement with observation both for short and long wave-lengths. Moreover, the observations of the authors enabled them to plot for various temperatures the curves $E = f(\lambda)$, which agree fairly well with those obtained from Thiesen's equation, but still better with those derived from the equation, $E = CT\lambda^{-4}\, e^{\frac{-c}{(\lambda T)^{1\cdot 3}}}$.

A Sylvin-prism was used to obtain the spectrum, and electrically heated

bodies were employed as the source of radiation; in the case of high temperatures the validity of this method was tested by comparative observations.
W. E. T.

371. *Radiation of Black Bodies.* **H. Rubens** and **F. Kurlbaum.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 41. pp. 929–941, Oct. 25, 1900.)—If the radiation from a black body be reflected from several surfaces of fluorspar the residual radiation consists of a complex with maxima of intensity for $\lambda = 24\,\mu$ and $\lambda = 31{\cdot}6\,\mu$. By means of a method founded on this property observations were obtained for long wave-lengths and high temperatures which enabled the authors to test the equations of Wien, Thiesen, Rayleigh, Lummer and Jahnke, and Planck. The residual radiation of rock-salt enabled them to examine the wave-length $51{\cdot}2\,\mu$. Temperature measurements were reduced in accordance with the latest determinations of Holborn and Day. The results of the observations are exhibited in curves, which show the invalidity of the equations of Wien, Thiesen, and Rayleigh, but which agree well with that of Lummer and Jahnke, except for extremely low temperatures, and which agree well with the equation of Planck for all temperatures. W. E. T.

372. *Dilatation of Metals.* **L. Holborn** and **A. Day.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 44. pp. 1009–1013, Nov. 8, 1900.)—Tables are given of measurements of the expansion of platinum, palladium, platinum-iridium (80 Pt, 20 Ir), and nickel up to 1000°, of silver to 875°, iron and steel to 750°, and constantan (60 Cu, 40 Ni) to 500°. The expansion of thin half-metre rods of the various metals in electrically heated porcelain tubes is observed through two holes in the tubes. In cases where oxidation takes place small platinum scales are fixed to the rods. With the exception of the magnetic metals the expansion can be accurately expressed as a function of the second degree, as is shown by the close agreement of the calculated and observed values. The expansions per unit of length are formulated as follows:—

Platinum	$(8868t + 1{\cdot}324t^2)10^{-9}$
Palladium	$(11670t + 2{\cdot}187t^2)10^{-9}$
Platinum Iridium	$(8198t + 1{\cdot}418t^2)10^{-9}$
Silver	$(18270t + 4{\cdot}793t^2)10^{-9}$
Nickel	$(13460t + 3{\cdot}315t^2)10^{-9}$
Constantan	$(14810t + 4{\cdot}024t^2)10^{-9}$
Iron	$(11705t + 5{\cdot}254t^2)10^{-9}$
Steel	$(9173t + 8{\cdot}336t^2)10^{-9}$

The formula holds for nickel above 375°, for iron up to 500°, and for steel up to at least 250°. The mean result for platinum varies only by 1 per cent. at 1,000° from the value extrapolated from Benoit's formula, which was deduced from observations made between 0° and 75°. G. E. A.

373. *Entropy and Heat Capacity.* **J. E. Trevor.** (Journ. Phys. Chem. 4. pp. 529–532, June, 1900.)—The author propounds the question, What is the relation between the entropy and the heat capacity of a system with respect to any reversible thermodynamic path?

We have $\eta = \dfrac{d(\theta\eta)}{d\theta}$, the differentiation being with η constant, and this interprets the entropy η as the increase of the store of heat $(\theta\eta)$ per degree of temperature θ produced from adiabatic work. This point of view is compared with that of Helmholtz (Ueber die Thermodynamik der chemischen Processen Ges. Abh. 2. 958, 1882).

In the general case the author obtains the equation, $\frac{d(\theta\eta)}{d\theta} = \frac{d'Q}{d\theta} + \eta$, $\frac{d'Q}{d\theta}$ being heat capacity.

The interpretation of this is that a system's entropy, plus its heat capacity with reference to any reversible path, is equal to the change per degree of the system's store of heat $\theta\eta$. The same principle is further illustrated by means of a diagram, showing the Carnot cycles between different values of θ and of η. If $\eta = 0$, $\eta = \eta_a$, $\eta = \eta_b$ be three adiabatics, we find the equation $\frac{d(\theta\eta)}{d\theta} = (\theta + 1)\eta_b - \theta\eta_a$, expressing the work value of the entire series of one degree Carnot cycles between $\eta = 0$ and $\eta = \eta_b$. S. H. B.

374. *Thermodynamical Properties of Steam.* **H. L. Callendar.** (Roy. Soc., Proc. 67. pp. 266–286, Nov. 14, 1900.)—*Assuming* for a vapour the characteristic—

$$v - b = RT/p - AT^{-n},$$

and writing V for the ideal volume RT/p and c for the "co-aggregation volume" AT^{-n}, A, R, b, n being constants, we have respectively for the isopiestic and isometric specific heats—

$$S = S_0 + n(n+1)Rc/V$$
$$s = s_0 + nR\left\{(1 + nc/V)(1 - c/V) - 1\right\},$$

where S_0, s_0 are functions of T, which are also obviously the specific heats for $p = 0$, $v = \infty$; and we have also—

$$S - s = R(1 + nc/V)^2,$$

so that—

$$S_0 - s_0 = R.$$

The intrinsic energy is then given by—

$$E - E_0 = \int_{T_0}^{T}(s_0 - nR)dT + np(v - b) - np_0(v_0 - b),$$

and the further *assumption* that the kinetic energy of the vapour is proportional to $p(v - b)$ therefore gives $s_0 = nR =$ const., and so $S_0 = (n+1)R =$ const., $\gamma_0 \equiv S_0/s_0 = 1 + n^{-1}$, and consequently—

$$S/S_0 = 1 + nc/V, \quad s/s_0 = (1 + nc/V)(1 - c/V),$$
$$\gamma \equiv S/s = \gamma_0/(1 - c/V),$$
$$E - E_0 = n\left\{p(v - b) - p_0(v_0 - b)\right\} = n\left\{R(T - T_0) - (pc - p_0c_0)\right\}.$$

The adiabatics in this case are given by—

$$p^n(v - b)^{n+1} = \text{const.}, \quad p/T^{n+1} = \text{const.}, \quad (v - b)T^n = \text{const.},$$

and the entropy by—

$$\phi - \phi_0 = S_0 \log(T/T_0) - R \log(p/p_0) - n(pc/T - p_0c_0/T_0).$$

The latent heat L and the total heat H of the vapour at T are connected with the saturation specific heat of the liquid Σ' by the relation—

$$L = H - \int_{T_0}^{T}\Sigma' dT,$$

and consideration of a simple cycle gives—

$$H - H_0 = S_0(T - T_0) - (n+1)(cp - c_0p_0) - \int_{p_0}^{p}(v' - b)dp,$$

where v' is the volume of the liquid at the saturation-pressure p corresponding to its temperature T, so that—

$$dH/dT = S - \left\{(n+1)c + v' - b\right\} dp/dT ;$$

hence L is calculable and also the saturation specific heat Σ of the vapour, which is equal to $dH/dT - L/T$.

The last *assumption* made is that for an N-atomic gas $\gamma_0 = 1 + 2/(2N + 1)$, so that for triatomic steam, to which the theory is specially applied, $n = 3{\cdot}5$.

In the case of steam b is taken as 1 c.c., and the experimentally deduced values of V and c at 100° C. under 76 cm. pressure are 1698 and 26·5 c.c. respectively, so that with pressures measured in atmospheres $R = 4{\cdot}552$, $A = 2{\cdot}656 \times 10^{10}$. Further, the calorie being taken as 4·180 joules, the value of R in cal./deg. C. is $4{\cdot}552 \times 1{\cdot}0133 \div 4{\cdot}180 = 0{\cdot}1104$, and thus $S_0 = 0{\cdot}4966$, $s_0 = 0{\cdot}3862$ with the same heat unit. Also Σ' may be taken as $1 + 0{\cdot}00022(T - 333)$ above 60° C., and a recent determination leads to 540·2 as the value of L at 100° C. With these data tables are calculated of the values of c, V, v, c/V, $(c - b)/V$, S, s, γ, H, L, Σ, and other functions for saturated steam at intervals of 20 degrees from 0° to 200° C., the saturation-pressures being experimentally known; and the deviations from Boyle's law are shown by plotting v/V against p, the isothermals on this diagram forming a system of *concurrent straight* lines. Some of the results are given in the following table :—

t	v	S	s	γ	H	L	$-\Sigma$
0°	202602	0·4973	0·3866	1·286	593·5	593·5	1·680
100°	1672·5	0·5236	0·4009	1·306	640·3	540·2	1·028
200°	129·6	0·6399	0·4568	1·401	673·4	471·1	0·759

These numbers differ very greatly from those obtained by Regnault, but agree fairly well with isolated results of later experimenters and with the author's as yet undescribed experiments.

The author then calculates the entropy of water and of steam in the saturated state at the above temperatures, and he also obtains theoretically an equation, equivalent to that of Dupré, which approximately gives the saturation-pressure in terms of the temperature: this he employs to calculate p, and compares his results with Regnault's, which seem to be slightly too small. [The author starts his calculations with these resulting pressures, but the comparison still holds good, as only the small correctional terms are affected.]

[Slight changes have been made in the notation for convenience.] R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

375. *Apparent Mass of the Ions.* **H. A. Lorentz.** (Phys. Zeitschr. 2. pp. 78–79; Discussion, pp. 79–80, Nov. 3, 1900. Paper read before the 72nd Naturforscherversammlung at Aachen.)—From observations on kathode rays has been derived the value of e/m, *i.e.*, of the ratio of the charge of an ion to its mass. But it may be asked, What is to be understood by this mass m? We are compelled to ascribe some mass to an ion, since its motion involves a certain energy in the ether. Let this apparent mass be denoted by m_0. Then $m_0 \leqq m$ and $e/m_0 \geqq e/m$, where $e/m = 10^7$. The ion being supposed a sphere of radius R, it is then calculated that

$$R \geqq \tfrac{2}{3}\, e \times 10^7,$$

but the value of e is, unfortunately, not known. Possible methods of inquiry which might throw light upon the problem were mentioned and discussed.

E. H. B.

376. *Poynting's Theorem.* **P. S. Wedell-Wedellsborg.** (Zeitschr. Phys. Chem. 35. pp. 603–607, Dec. 7, 1900.)—This is a reply to Mie's paper [Abstract No. 2438 (1900)], and consists of a direct attack on Poynting's theorem. According to the author, Poynting and Thomson in their published writings affirm: (1) A constant current in a wire does not produce any charge on or in the conductor. (2) The lines of electric force are, in the neighbourhood of the conductor, parallel to the latter except when it has a statical charge. (3) The tubes of electric force, in the field round the current, move so that their direction of motion in the neighbourhood of the conductor is perpendicular to the latter.

On the other hand the author maintains: (1) The constant current always charges the inside and outside of its conductor, the density of charge at a point being proportional to the potential at the point. (2) Hence the lines of electric force are nearly perpendicular to the surface of the conductor, and their angle of inclination changes from point to point, being zero where the potential is zero. (3) The direction of motion of lines of electric force is not perpendicular to the conductor, but parallel to it, and no tubes of force move through the surface of the conductor. G. E. A.

377. *Magneto-electric Forces.* **H. Lorberg.** (Ann. d. Physik, 3. 3. pp. 522–529, Nov., 1900.)—The author criticises the rival explanations of Pohl's rotation experiment advanced by Lecher [see Abstract No. 94 (1900)] and König [see Abstract No. 2232 (1900)], from the point of view of the old current-element theory. By the principle of the equality of cause and effect, from which it follows that the two couples due to the action between a current-element and a pole are equal and opposite with respect to any assignable axis, and that therefore the two opposite forces go through the same point, and consequently through the current element, Lecher's experiment is very simply explained. The latter has no connection whatever with Pohl's experiment. Lecher is quite right in maintaining that in Pohl's experiment the cause of the rotation is not to be sought in the axial portion of the current, but in the remainder of the circuit. The same theorem is put down in the author's text-book of Physics. E. E. F.

378. *Electric Pressure.* **J. B. Pomey.** (Écl. Électr. 25. pp. 311–313, Nov. 24, 1900.)—In an electrostatic field, the expression of the components of the pressure along the axes of *x*, *y*, and *z*, at a point where the intensity of the field has components X, Y, and Z, is given by

$$P_x = \frac{k}{8\pi}\{2X(lX + mY + nZ) - l(X^2 + Y^2 + Z^2)\} \qquad (1)$$

and two corresponding equations for P_y and P_z; l, m, and n being the direction cosines of the normal to the surface. This equation may also be put in the form—

$$P_x = \frac{k}{2}(\sigma X + \tau_z Y - \tau_y Z), \qquad (2)$$

if one writes—

$$4\pi\sigma = lX + mY + nZ; \qquad (3)$$

also—

$$\left.\begin{aligned} 4\pi\tau_x &= nY - mZ,\\ 4\pi\tau_y &= lZ - nX,\\ 4\pi\tau_z &= mX - lY, \end{aligned}\right\} \qquad (4)$$

and—

Corresponding equations express P_y and P_z. When thus written, it may be seen that the force P_x, P_y, P_z is half the resultant of two forces. Of these the first, $k\sigma X$, $k\sigma Y$, $k\sigma Z$, is the action which would be exerted by a field of intensity X, Y, Z, upon an imaginary quantity of electricity $k\sigma$. The second force, which has for its components three expressions analogous to $k(\tau_z Y - \tau_y Z)$, is the action which would be exerted by a *magnetic* field of intensity X, Y, Z, on an element of *current* of which the superficial density is $k\tau_x$, $k\tau_y$, $k\tau_z$. The author then proceeds to discuss the existence of this second force.

E. H. B.

379. *Evaporation of an Electrified Liquid.* **W. C. Henderson.** (Phil. Mag. 50. pp. 489–497, Nov., 1900.)—An account is given of experiments made to determine whether a liquid when electrified loses any portion of its charge by evaporation. The loss of charge from an insulated vessel as observed by noting the change of deflection on the scale of a quadrant electrometer was found to be the same whether the vessel was empty or contained a liquid. Experiments were made with water at ordinary temperatures, water heated to near the boiling-point, and with ether which evaporated rapidly at the ordinary temperature of the room. In each case the result was to negative the theory of a loss of charge by evaporation. In the first set of experiments a loss of charge of $0{\cdot}86 \times 10^{-6}$ c.g.s. per second per sq. cm. could have been detected, and in another set with a somewhat modified apparatus the minimum loss of charge which could have been detected was $1{\cdot}06 \times 10^{-6}$ c.g.s. per second per unit area. These results are in opposition to the recently published observations of Pellat. J. J. S.

380. *Air Potentials during Total Eclipse.* **J. Elster.** (Phys. Zeitschr. 2. pp. 66–67, Nov. 3, 1900.)—Above Algiers, during last May's eclipse, shortly after totality a decided minimum in the atmospheric potential-gradient was observed. A. D.

DISCHARGE AND OSCILLATIONS.

381. *Retardation of Discharge.* **R. Swyngedauw.** (Journ. de Physique, 9. pp. 487–493, Sept., 1900.)—The author describes his experiments on the discharge of an exciter consisting of two metal balls placed a short distance apart, one being insulated and the other joined to earth. Warburg considered from the results of his experiments that in darkness the retardation of discharge is considerable, and that in ultra-violet light the retardation is diminished. The author comments on Warburg's experiments, and finds from his own that exciters, when carefully *polished* and *placed in an open space*, do not present any retardation of discharge. Warburg's results with ultra-violet light were observed only if the exciter was illuminated during the short time of charge. The author considers that Warburg's experiments confirm the proposition which he formerly stated : Under the action of the ultra-violet rays the lowering of the explosive potential is a function increasing with the velocity of variation of the potential between the poles of the exciter.

J. J. S.

382. *Action of Radiation on the Spark Discharge.* **E. Warburg.** (Deutsch. Phys. Gesell., Verh. 2. 15. pp. 212–217, 1900.)—The author's explanation of the action of radiation on the spark discharge has been opposed by R. Swyngedauw [see preceding Abstract], and in this paper the author again states his views and gives his reasons for disagreeing with Swyngedauw.

The spark apparatus consists of two metal balls A and B ; A joined to earth, B raised to an increasingly high potential. Two cases have to be considered.

I. In the *first case* the potential of B is slowly raised.

(1) When the spark apparatus is exposed to the rays, the retardation which is usually great causes the exact determination of the spark potential to be difficult or impossible.

(2) The passage of the spark takes place under the influence of the rays when the potential reaches a definite value—no retardation is observed. This value is independent of the nature of the radiation.

(3) In some cases the spark potential is a little smaller with than without the radiation ; in other cases this difference changes completely. This difference seems to have no greater meaning than the change which can be observed between the melting- and freezing-point of over-cooled liquids ; and the author considers the values of the spark potential found by spark apparatus exposed to radiation to be the normal values of this magnitude, *i.e.*, values not influenced by passive resistances. According to this explanation in case I. the simple action of the radiation is the raising of the retardation ; a reduction of the spark potential due to the radiation does not take place.

II. In the *second case* there is a different *apparent* behaviour in known cases in which the potential of the electrode B is quickly raised, as, for example, when having been previously connected to earth, it is suddenly joined to the inner coating of a charged jar. It is found in this case under some circumstances that with ultra-violet radiation the spark takes place if the potential of the jar is considerably lower than the spark potential determined in case I.

Swyngedauw explains this phenomenon in conformity with the proposition brought forward by him that by the ultra-violet radiation the spark potential is lowered and the more so the quicker it is raised by the charging up. But it is necessary to take into consideration the fact that in these experiments the spark apparatus becomes charged under damped oscilliations on account of the connection to the jar, on which account the potential difference of the electrodes from time to time takes a higher value than the potential of the jar. If the capacity of the spark apparatus compared with that of the jar can be neglected, and for the first half vibration the damping also, then the maximum potential difference attained is double that of the jar. Hence it is possible that the lowering of the spark potential recorded by Swyngedauw is only an apparent one, as the potential difference of the electrodes may at times attain a value equal to or exceeding the normal spark potential.

The author describes experiments and gives calculations illustrating his views, and in the result comes to the conclusion that the action of the ultraviolet rays on the spark discharge consists entirely in a change of the retardation, not in a reduction of the spark potential, whether the potential difference acts for a long or a short time on the spark apparatus. This result stands in complete opposition to the statement of Swyngedauw. J. J. S.

383. *Colour-Rings on Crystalline Plates under Kathode Rays.* **W. B. v. Czudnochowski.** (Phys. Zeitschr. 2. pp. 65–66, Nov. 3, 1900.)—Colourless fluorspar under the continued action of kathode rays from a concave kathode develops superficial colours appearing and spreading in the order grey, yellow, orange, brown-yellow, violet, yellow, red, violet. A. D.

384. *Action of the Coherer.* **T. Mizuno.** (Phil. Mag. 50. pp. 445–459, Nov., 1900.)—When a metallic powder is exposed to the influence of electric radiation its resistance changes, and the results of experiment tend to show that the action of the coherer is correlated in some way to the microscopic sparks produced in an assemblage of fine metallic particles in virtue of the action of electric waves. These sparks may give rise to a "welding" action with the consequent formation of conducting chains of particles and lessening of the resistance of the coherer.

The author made a series of experiments on a number of metals, some alloys, and their mixtures. The source of electric waves was a Hertzian parabolic vibrator, emitting electric waves of about 60 cm. wave-length. The coherer consisted of a glass tube about 5 cm. long, 5 mm. in diameter, having two movable and finely adjustable small pistons, between which the metallic powder could be introduced. From the extremities of the pistons wires were led to the arms of a Wheatstone's bridge. The galvanometer used was a Kelvin's astatic double-coil one. The bridge-current was supplied by a single Daniell cell, the resistance, ranging between 1,000 and 2,000 ohms, being always inserted in the circuit before the current entered the arms of the bridge. This precaution was necessary because when the current exceeded a certain strength the resistance of the coherer often underwent very marked spontaneous fluctuations during the repeated processes for balancing the bridge. The author studied the history of the successive changes of the resistance of the coherer accompanying successive oscillating sparks of the Hertzian vibrator, and gives his results in tables and diagrams. He sums up the chief results obtained as follows:—

(1) In platinum, lead, nickel, aluminium, cadmium, copper, steel, silver and potassium coherers, the action of electric waves is to reduce their resistances at first to a large extent, and then this reduction continues, though

with some intermediate rise and fall, until the resistances assume certain final values.

(2) In the case of iron, tin, bismuth, zinc, and antimony coherers, their resistances are diminished at first, but soon afterwards the changes become very irregular, the diminution and increase occurring at random. With the iron coherer the action is conspicuously irregular.

(3) With one and also two small lead-ball coherers the resistance attains its final value very rapidly, so that the successive stages of their histories present nothing conspicuous.

(4) In the alloys, namely German-silver, brass, electric fuse, ordinary solder, Rose's and Wood's metals, the general tendency is to the reduction of their resistances to certain limiting values, though with more or less irregularity.

(5) In the case of the coherers with the mixed metals, namely, iron with silver, cadmium, Rose's and Wood's metals respectively, and also silver with Wood's metal, the mode of change of resistance seems to be chiefly governed by the percentage ratios of the constituents. The history of each coherer presents the character which would belong to the predominating constituent.

(6) With zinc, lead, potassium, and electric fuse, the resistance suddenly assumes infinite value at a certain stage during the experiment.

The results appear to support the view that the action of the coherer may be due to something like welding taking place on a small scale among fine metallic particles in consequence of the induced microscopic sparks. The lowering of resistance seems to be greatly determined by the melting-point of each metal and alloy, the lower the melting-point the greater being the reduction. This reduction also evidently depends upon the specific electric conductivity. J. J. S.

385. *Coherers and Decoherence.* **G. Ferrié.** (Ecl. Électr. 24. pp. 499–503, Sept. 29, 1900. Paper read before the International Electrical Congress at Paris.)—The writer extends the experiments of Hughes, Lodge, Tommasina, Popoff, and Branly, using coherers of carbon-carbon, carbon-metal, metal-metal, metal-liquid, in air, oil, and vacuum respectively. Carbon-carbon is comparatively less sensitive than the other combinations; the coherence is of unstable resistance, but tends to persist. Carbon-metal gives more certain contact, and contact may conveniently be restricted to a single point; the best results were obtained from polished granules of carbon 0·5 mm. diameter, in a glass tube provided with metallic electrodes, of Pt, Au, Ag, Ni, Cu, Zn, &c. The results with metals were always better than when using carbon electrodes. In general, the most effective coherer is one having a resistance of from 1,000 to 25,000 ohms, working with a current less than a milliampere. If the initial resistance is too high, the effects are feeble and generally disappear. If the resistance is too low, the effects at first may be striking, but they may suddenly cease. If the initial resistance is infinite, the action is irregular; the strong impulse necessary for coherence will probably cause persistent contact. Zinc and its alloys give the greatest sensitiveness. Nickel and platinum give the most regular results. The degree of oxidation has great influence on the sensitiveness. For different metals the distance between the coherer and the oscillator appears to have different effects. With zinc, the sensitiveness over a long range is fairly constant, and then ceases abruptly. Nickel-carbon and platinum-carbon are comparatively very sensitive at the longer distances. Coherence and decoherence effects can be obtained between liquids and

metal; the best results were with acidulated water and a dipping wire touching just at the surface. Copper, which is attacked by the acid, gives better effects than platinum. Carbon-metal, and metal-metal in petroleum behave as in air—if anything, the arrangement is slightly less sensitive in petroleum. The vacuum experiments were inconclusive, owing to air films. The paper concludes with a speculation as to the action of coherence and decoherence. R. A.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

386. *Electrocapillarity.* **Gouy.** (Comptes Rendus, 131. pp. 835–837, Nov. 19, 1900.)—It appears that in a capillary electrometer there is at the mercurial surface an elective action which produces an accumulation of anions of some salts in preference to those of a less active or an inert salt (iodides rather than bromides for example). The state of final equilibrium between the ions is broken when the surface is varied, and is restored more slowly the fewer the active anions in proportion to the others: and this is the cause of electrocapillary viscosity. A. D.

387. *Conductivity of Gases when Carrying Electric Discharges.* **J. Stark.** (Ann. d. Physik, 3. 3. pp. 492–512, Nov., 1900.)—This paper contains a summary of all the papers which have been published on the measurement of the conductivities of the gas at the different parts of a vacuum tube carrying an electric discharge. The general method adopted for determining the conductivity consists in measuring the difference of potential and the electric current between two small subsidiary wire electrodes. These are placed on an equipotential surface of the main discharge and are joined in circuit with a small electromotive force. The theory of the method is considered in the present paper. The general conclusions arrived at are: (1) The strength of the cross current is independent of the potential gradient of the main discharge, and it gives an approximate value of the conductivity of the gases at the position of the transverse electrodes. (2) The conductivity in gases carrying a discharge varies from place to place; it is, as a rule, greater in the luminous parts than in the neighbouring dark spaces. (3) The variation of conductivity from place to place does not correspond everywhere to the variation of the potential gradient. This is explained by the presence of internal differences of potential (4) Owing to the ionising action of the charged particles the conductivity of a gas increases with the current strength. (5) The electric current also alters the concentration of the ions and consequently the conductivity, by the variation of the strengths of the positive and negative currents from place to place. J. B. H.

388. *Thermo-elements for the Measurement of High Temperatures.* **S. Lindeck** and **R. Rothe.** (Zeitschr. Instrumentenk. 20. pp. 285–299, Oct., 1900.)—Details are given of the methods of testing thermoelectric apparatus for the measurement of high temperatures as carried out at the Reichsanstalt in Berlin. The first part of the paper describes the furnaces used and the arrangement of the junctions in them. In later experiments the thermo-elements of Le Chatelier's form were compared in electrically heated furnaces, constructed as described by Holborn and Day, which consist of several concentric tubes, the inner tube containing the thermo-electric junction and the one next it the wire whose rise of temperature on the passage of a current causes the heating of the furnace. These tubes are formed of a highly infusible sort of porcelain. For temperatures up to 1,400° the material used for the heating-wire is nickel. For higher temperatures up to 1,600° and 1,700° platinum-iridium is used.

The second part of the paper gives full particulars of the method of measurement of the e.m.f. by a compensation arrangement. J. J. S.

389. *New Measuring Instruments of Siemens and Halske.* **A. Franke.** (Elektrotechn. Zeitschr. 21. pp. 891–894, Oct. 25, 1900.)—The first two of these instruments are developments of the wattmeter for use with both alternating and continuous currents described in the Elektrotechn. Ztschr. 20. pp. 665–670, September 14, 1899 [see Abstract No. 176 (1900)]. The main points of difference between this wattmeter and the ammeter or voltmeter are first discussed, viz.: In the latter, the influence of eddy-currents is not so deleterious, since the difference of phase of the currents in the fixed and movable coils (which are connected in series) is zero in the voltmeter, and can be made zero or very nearly zero in the ammeter. The instrument can thus be made of metal with the exception of the bobbins. The second difference is that the deflections do not follow a straight-line law; an open scale is however obtained when about 0·2 to 0·25 of the range is passed. In the voltmeter, by making, for example, 0·1 of the resistance of copper, and the rest of manganin wire, the temperature coefficient of the instrument can be made less than a tenth of the temperature coefficient of the copper and can thus be neglected for practical purposes. Since the self-induction of the whole system only varies between 0·038 and 0·054 henry from one end to the other of the scale, with a resistance of 800 ohms, the difference between the apparent and the ohmic resistance is less than $\frac{1}{10}$ per cent. at 100 periods per second, and no correction is required for self-induction. By removing a plug the range of the instrument can be doubled. In the ammeter the fixed and movable coils are connected in parallel, so as to enable the current in the movable coil to be less than that in the fixed coil. Inductionless resistance, which does not vary with temperature, is arranged in each of the circuits, so as to reduce the temperature coefficient of the instrument to a quarter of that of the copper. The difference between the readings with direct currents and with alternating currents of 100 periods per second is less than $\frac{1}{10}$ per cent. The range can be increased by inserting a resistance in the circuit carrying the stronger current (*i.e.*, the fixed coil circuit). The instrument consumes 40 watts at its maximum deflection.

Some portable direct-current Deprez-d'Arsonval-pattern instruments are also described. In these instruments the movable coil is stretched between two metal bands which serve to centre it and also to provide the directive force. The whole movable system, including a light aluminium pointer, only weighs 0·6 gramme. The damping of these instruments is effected in two ways, viz.: By a shunt to the movable coil where the sensitiveness is greater than is required; and by a closed circuit on the movable coil itself. It has a sensitiveness of 15.10^{-6} ampere per division. Various forms of this instrument are described with photographic illustrations. C. K. F.

390. *Modified Wehnelt Interrupter.* **J. v. Pallich.** (Ann. d. Physik, 3. 3. pp. 543–544, Nov., 1900. From the Akademische Anzeiger d. K. Akad. d. Wissensch. zu Wien, xii. Sitzung vom 3 Mai, 1900.)—The author describes a form of Wehnelt interrupter in which the lead plate is replaced by a copper wire, and the platinum anode by a steel wire. Both wires are enclosed in glass tubes, that containing the steel wire being strong, and tightly surrounding

the steel tip. Both wires dip into dilute sulphuric acid. The steel wire is 1 mm. or 2 mm. thick, and its upper end is held in a cork provided with a cup for a mercury contact. The vessel containing the sulphuric acid is surrounded by cold water to keep the temperature down. The two glass tubes with their wires are inserted in a rubber stopper provided with holes to allow the acid to flow back into the bottle in case it spurts out. A curious phenomenon noticed in the working of the instrument is that the steel wears away just where the wire emerges from the glass tube, and not in the portion more immersed in the acid. A constriction is thus formed, and the effect appears to be that its formation assists rather than retards the generation of the gaseous layer, the explosions becoming stronger and more abrupt as the work of the interrupter continues. The double adjustment possible in this type of instrument makes it particularly easy to obtain the necessary current strength. E. E. F.

ALTERNATING CURRENTS AND MAGNETISM.

391. *Experimental Tracing of E.M.F. and Current Waves in the Rotors of Induction Motors.* **H. Rupp.** (Elektrotechn. Zeitschr. 21. pp. 820–822, Oct. 4, 1900.)—To render the ordinary Joubert-contact methods applicable to the rotor currents of an induction motor, it becomes necessary to drive the contact-disc at a speed corresponding to the slip of the rotor. One way of doing this is to connect the stator circuits of a synchronous motor to the rotor circuits of the motor under investigation; the rotor of the synchronous motor, which carries the contact-disc, being polarised by a suitable continuous current fed into it by means of slip-rings. Under these conditions, however, the induction motor does not run as under normal conditions of working, the counter-e.m.f. of the synchronous stator reacting on the rotor of the induction motor. An arrangement which more nearly conforms to the practical conditions of working is that in which the rotor circuits are closed through the starting resistance, the stator of the synchronous motor being coupled in parallel with the starting resistance. Another device described by the author consists of an auxiliary motor which rotates synchronously with the stator field of the motor under investigation, whose rotor is placed in line with that of the auxiliary motor. On the shaft of the auxiliary motor is mounted a disc carrying a couple of brushes placed side by side but insulated from each other and connected to two slip-rings. These brushes bear on the inner surface of a ring of fibre attached to the pulley of the induction motor and provided with a strip of metal which momentarily connects the brushes as it passes under them. The slip-rings in connection with the brushes are placed in circuit with a condenser and joined across the brushes of the rotor of the induction motor. The circuit will be periodically closed for a certain relative position of the stator field and the rotor. In order to vary this position, and so obtain a number of points on the curve, the stator of the auxiliary synchronous motor may be made movable round the rotor shaft. The same effect may be produced electrically, by altering the phase of the stator field without any mechanical rotation, as follows: A second auxiliary induction motor has a rotor provided with an index moving over a scale and capable of being clamped in any required position; the adjustable rotor is connected across the supply mains, while the currents induced in the stator windings of this auxiliary motor are used for supplying the stator windings of the auxiliary synchronous motor. Changing the position of the fixed rotor is obviously equivalent to a rotation of the stator of the synchronous motor. The author gives a number of curves obtained by the methods described; the curves appear to differ very little from the pure sine form. A. H.

392. *Magnetic Deposits formed in a Magnetic Field.* **C. Maurain.** (Comptes Rendus, 131. pp. 880–881, Nov. 26, 1900.)—In continuation of his former work [see Abstract No. 2235 (1900)], the author gives the results of a comparison of (1) the magnetisation of an electrolytic deposit of iron formed in a magnetic field of given strength with (2) that which a similar deposit, not formed in a magnetic field, acquires when afterwards subjected to a field increasing from zero to the strength of the preceding field. The electrolytic bath employed consisted of ammonium oxalate and double oxalate of iron and ammonium, the magnetisation of the deposits obtained being more regular and more intense than with those formed by the pyrophosphate bath formerly used. In case (1), the curve with the values of I as ordinates and those of H as abscissæ is very steep, the value of I/H being at first very great, and only diminishing when a strength of field of about 10 gausses is attained; this curve has no point of inflexion such as occurs in the ordinary curve of case (2). T. H. P.

393. *Hadfield's Nickel-Manganese Steel.* **E. Wilson.** (Electrician, 46. pp. 85–86, Nov. 9, 1900.)—The sample contained Ni 25, Mn 5·04, and C 0·8 per cent. It was found to be practically non-magnetic. The specific resistance is $88{\cdot}3 \times 10^{-6}$, and the temperature coefficient 0.088 per cent. per 1° C. W. H. E.

394. *Currents and Voltages in Polyphase Systems.* **C. E. Guye.** (Comptes Rendus, 130. pp. 1382–1383, May 21, 1900.)—The problem of finding the voltages and currents when the polyphase mains possess capacity and are affected by mutual and self-induction is solved analytically. It is shown that the problem can be reduced to that of a single-phase main which possesses self-inductance L′, and capacity K′ per unit length where L′ and K′ are determined by the equations—

$$L' = L_{1\cdot 1} + 2L_{1\cdot 2} \cos \frac{2\pi}{n} + 2L_{1\cdot 3} \cos \frac{4\pi}{n} + \ldots$$

in which $L_{1\cdot 1}$ is the self-inductance of the main, and $L_{1\cdot 2}$ the mutual inductance between the mains 1 and 2, &c.; and—

$$K' = K_{1\cdot 1} + 2K_{1\cdot 2} \cos \frac{2\pi}{n} + 2K_{1\cdot 3} \cos \frac{4\pi}{n} + \ldots$$

These equations enable us to solve the problem of finding the voltages and currents when they have attained their steady state. [See also Abstracts Nos. 1308 and 1868 (1900).] A. R.

MEDICAL ELECTRICITY.

395. *The Law of Dubois-Reymond and Measurements in Electro-biology.* **Dubois.** (Revue Int. d'Électrothérapie, 10. pp. 230–238, Aug., 1900. Paper read before the International Congress of Electro-biology at Paris, 1900.)—Inasmuch as the phenomena of muscular contraction can be produced equally well by battery currents or by discharge from an induction coil, a static machine, or a condenser, there is probably some condition common to all these modes of stimulation.

Experiments with condenser discharges show that as the charging potential is increased the required capacity of the condenser decreases rapidly; for example, the minimal contraction in the muscles of man is obtained with a capacity of 0·48 microfarads charged at 12·6 volts, with 0·017 at 35 volts, and with 0·007 at 70 volts, the capacity in the last example being seventy times less than in the first, while the potential is only six times greater. In man a minimum potential of about 12 volts is necessary, and discharges at lower potentials are ineffective, whatever the capacity of the condenser. If the energy of the condenser discharges be calculated, it appears that at low potentials it is relatively large; that as the potential is raised and the capacity is diminished the energy required becomes less until a point is reached, after which it again increases; there is a relation between potential and capacity such that a point can be found at which the minimal contraction is produced with a minimum expenditure of energy. Energy is wasted in the case of the large condenser at low potential because much of the discharge is below the effective minimum of 12 volts; while in the case of a small condenser and a high potential there is waste because the duration of the discharge is too short. In the case of a large capacity and a low potential, the rate of discharge may also be too gradual to be effective owing to the resistance of the patient's skin. The view of Dubois-Reymond that the effect on a muscle varies simply with the magnitude and rate of change of the stimulating current holds good to a modified extent only. The discharge of a Tesla coil fails because the individual impulses of which it is made up have too short a duration. H. L. J.

396. *Dependence of Therapeutic Effects on Frequency.* **G. Gautier** and **J. Larat.** (Revue Int. d'Électrothérapie, 10. pp. 225–227, Aug., 1900.)—The authors have compared the therapeutic effects of sinusoidal currents of ordinary (low) periodicities with those of the high-frequency apparatus of Tesla and d'Arsonval. They consider that the former are the more effective in promoting general nutrition and in correcting defective nutrition, but they regard the latter as being more suitable for the treatment of certain cutaneous affections. H. L. J.

397. *Phototherapy in Surgery.* **A. V. Minine.** (Revue Int. d'Électrothérapie, 10. pp. 193–204, July, 1900.)—The author finds that good results have followed from the application of light for the relief of pain. He uses an incandescent lamp of 50 candle-power (or 16 c.p. in some cases) with a reflector, and the lamp is held near to the painful part for ten or fifteen minutes every day or every other day. Its application markedly reduces the pains and the swellings of rheumatism, of bruises and of inflamed parts. In neuralgias it may at first increase the pain, but the after effect is good. Five cases are reported. H. L. J.

398. *Electrical Treatment for Pulmonary Tubercle.* **H. Guimbail.** (Revue Int. d'Électrothérapie, 10. pp. 248–252, Aug., 1900. Paper read before the Société Médicale de Monaco, March 24, 1900.)—The author has successfully treated a case of pulmonary tuberculosis by statical applications to the affected part; two metal plates were used, one on the chest and the other on the back. They were of the size of a five-shilling piece, and the discharge was passed between them through the chest. The patient gained in weight and lost his symptoms. H. L. J.

399. *Electrical Treatment of Tuberculosis.* **Jacquin.** (Revue Int. d'Électrothérapie, 10. pp. 252–258, Aug., 1900.)—The author treated a case of confirmed pulmonary disease by sparks from a statical machine applied to the region of the chest over the affected area of the lung. There were two applications of ten minutes daily for three months, followed by one application daily for three months more. Treatment was begun in March, 1898. The case still continued in good health at the date of the paper. H. L. J.

400. *Electrical Treatment of Fibroma.* **A. Zimmern.** (Archives d'Él. Médicale, 8. pp. 481–501, Oct., 1900.)—A review of the treatment of uterine fibroma by electricity. After describing in detail the method of procedure the author concludes by saying that the current probably acts by causing a cicatricial condition of the lining of the uterus, by setting up contractions in the muscular tissue of the organ, and by causing coagulation of the blood in the vessels. He regards the method as a good one. The paper itself is not suitable for a brief abstract, and should be referred to. H. L. J.

401. *Voltmeter or Milliammeter in Exploring the Excitability of Nerve and Muscle.* **E. Huet.** (Archives d'Él. Médicale, 8. pp. 433–448, Sept., 1900.)—In testing the excitability of muscles two methods have been advocated, the one by a comparison of the minimum currents required to provoke contractions, and the other by a comparison of the minimum e.m.f.'s needed to produce them. It has been shown by Dubois (of Berne) that the presence of self-induction in the testing circuit, by retarding the rise of current after closing the circuit, affects the magnitude of the current needed for producing a contraction ; but on the other hand a comparison of e.m.f.'s may also give a wrong impression because of the great variations in the resistance of the skin of different parts of the body. He shows that when the same case is tested on successive days the variations in the e.m.f.'s are much more irregular than those of the milliamperes ; and that a thorough moistening of the skin will cause a much greater change in the e.m.f.'s than in the currents required to produce the minimal contractions. He therefore prefers the milliampere readings to the readings of the voltmeter, but when great accuracy is needed he would make comparisons by both methods. H. L. J.

REFERENCES.

402. *Electrical Units and Standards.* (Amer. Inst. Elect. Engin., Trans. 17. p. 609 ; Discussion, pp. 610–618, Nov., 1900.)—Report of Kennelly's Committee on the subject, together with the discussion thereon.

403. *Inductance of Concentric Cables.* **W. H. Everett.** (Elect. Rev. 47. pp. 731–732, Nov. 9, 1900.)—The author gives formulæ for calculating the inductance of concentric and triple-concentric cables, both for three-wire and three-phase circuits, and gives some practical examples showing the loss of volts due to this inductance. G. H. B.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

404. *Molecular Constitution of Water.* **W. Sutherland.** (Phil. Mag. 50. pp. 460–489, Nov., 1900.)—The author discusses the physical properties of water and their bearing on its molecular constitution, and comes to the following conclusions: Ordinary water-vapour being H_2O, which it is proposed to call internationally hydrol, ice is trihydrol $(H_2O)_3$, and water a mixture of trihydrol and dihydrol $(H_2O)_2$, in proportions depending upon the temperature. Probably at its critical temperature water is practically pure dihydrol. The latent heat of fusion of ice is not an ordinary physical latent heat of fusion, but is mostly a latent heat of dissociation of trihydrol into dihydrol, partly masked by heat of solution of trihydrol in dihydrol. The latent heat of evaporation of water includes also the heat of dissociation of the dihydrol and trihydrol of water into the hydrol of steam. The specific heat of water is not an ordinary specific heat, but includes a certain amount of heat of dissociation. Pressure dissociates trihydrol. J. J. S.

405. *Velocity of Solution of Solid Substances.* **L. Bruner** and **S. Tolloczko.** (Zeitschr. Phys. Chem. 35. pp. 283–290, Nov. 2, 1900. Paper read before the Versammlung Polnischer Naturforscher u. Aerzte at Krakau, June 24, 1900.)—It was shown by Noyes and Whitney in 1897 that the velocity of solution of lead chloride and benzoic acid followed the logarithmic law, according to the formula $dx/dt = K(C - x)$, where C is the concentration of the saturated solution, x the concentration at the time t, and K a constant. The authors have experimented with a number of other substances—gypsum, acetanilide, phenylacetic acid, phenylpropionic acid, and benzoic acid—a definite quantity of each being fused, cast into a regular form of known surface, and attached to a mechanical stirrer immersed in water at a constant temperature. Portions of the solution were withdrawn from time to time and the concentration determined. The formula given above is confirmed, and, in addition, the value of the constant per square centimetre of surface has been determined. The system, solid substance—unsaturated solution, is considered to be practically unrealisable, and the solid substance is regarded as being in contact with a layer of saturated solution from which diffusion takes place into the surrounding liquid. The constants found are therefore diffusion constants, and the method described affords a convenient method for the determination of the diffusion constants of substances which are soluble with difficulty. N. L.

406. *Solubility of Manganous Sulphate.* **F. G. Cottrell.** (Journ. Phys. Chem. 4. pp. 637–656, Nov., 1900.)—The solubilities of the hydrates with 1, 4, 5, and 7 molecules of water of crystallisation have been determined. The author points out errors in Linebarger's work on the same subject, and shows that the above system offers no singularities. Attention is, however, drawn to the slowness with which systems containing the monohydrate as solid phase attain equilibrium. F. G. D.

407. *Berthier's Method for Determining the Calorific Value of Fuels.* **U. Antony** and **E. di Nola.** (Rivista Sci. Industriale, 32. pp. 222–223, Oct. 10, and 226–229, Oct. 20, 1900. From the Gazzetta Chimica Italiana.)—Two common objections to Berthier's method of measuring the calorific value of fuels, in which the lead obtained on heating the fuel with litharge is weighed, are (1) that volatile products are evolved at temperatures lower than that at which reduction of the litharge takes place, and (2) that the heats of combustion of the different elements of the fuel are not proportional to the amounts of oxygen which they take up on burning. From a number of trials with different kinds of coal, the authors conclude that, if care is taken to heat the mixture of fuel and litharge slowly, reduction of the latter occurs without the evolution of any volatile matter. In the case of ordinary fuels, the error introduced into the calculation of calorific power by assuming that all the lead obtained is due to carbon is very small and may be neglected. The available hydrogen in a fuel may be measured by heating it in a graphite crucible with lead fluoride, the reduction of which to metal is due entirely to the hydrogen. If p_C is the quantity of lead obtained by the reduction of litharge, and p_H that formed from the fluoride, the calorific power of the fuel in calories is given by the formula—

$$P = \frac{p_C}{84{\cdot}5} \times 8083 + \frac{p_H}{103{\cdot}5} \times 29367.$$

T. H. P.

408. *Coagulation of Turbid Media.* **W. Spring.** (Archives des Sciences, 10. pp. 305–321, Oct., 1900. *Résumé* of a paper in the Bulletin de l'Académie de Belgique, July, 1900.)—The author describes experiments on the coagulation ("flocculation") of water containing finely divided resin, &c., in suspension, by means of salts and acids, from which he draws the following conclusions: (1) Solutions of salts which cannot be obtained in an optically clear condition (*état optiquement vide*), *i.e.*, those which are hydrolysed by water, possess the power of coagulating such turbid solutions in a very high degree; this depends partly on the high agglutinative action of the metallic hydroxide produced on hydrolysis of the salt, and partly on the powerful flocculating power of the acid. (2) Coagulation cannot be brought about by those electric actions which produce discharge at a distance or create an electric field by influence; the action is therefore of a kind different from that involved in the precipitation of dust or smoke from the air. (3) Any electric current, no matter how feeble, produces flocculation which proceeds quicker as the current intensity increases. (4) Electrolytes of the same conductivity and containing the same kation bring about flocculation of the same solution in the same period of time. When the kations are different the speeds of coagulation are in the same order as the velocities of the kations. (5) The nature of the anions seems to play a secondary or even a negligible part in this phenomenon. T. H. P.

409. *Heat of Combustion of very Volatile Liquids.* **Berthelot** and **Delépine.** (Annal. Chim. Phys. 21. pp. 289–296, Nov., 1900.)—The determination of the heat of combustion of volatile liquids in the calorimetric bomb is subject to errors caused by the partial volatilisation of the substance or by its slow oxidation by the compressed oxygen. In such cases the liquid is enclosed in a sealed glass bulb, which is broken at the desired moment by the explosion, effected by electrical means, of a weighed quantity of a mixture of camphor and guncotton. The calorimetric value of the latter is previously determined and the corresponding correction made. The molecular heats of combustion of a number of volatile liquids have been determined by this process with the following results: Acetaldehyde, 278·86

cal. ; methylal, 461·9 cal. ; methyl formate, 288·2 cal. ; ethyl formate, 391·4 cal. ; propionaldehyde, 433·8 cal. ; acetone, 426·3 cal. N. L.

410. *Combustion of Gases.* **S. Tanatar.** (Zeitschr. Phys. Chem. 35. pp. 340–342, Nov. 2, 1900.)—Bunsen explains the influence of dilution with neutral gases in preventing the explosion of gaseous mixtures as due to the lowering of the temperature of combustion below the ignition-point. This explanation cannot be given in the case of mixtures of $2H_2 + O_2$ (produced by electrolysis) with hydrocarbons. A mixture of hydrogen and oxygen in equivalent proportions becomes non-explosive when only 11–12 per cent. of propylene is added, and a similar effect is produced by the isomeric trimethylene. The hydrogen of the explosive mixture remains unburnt, and no large amount of carbon dioxide is produced, the products of combustion being carbon monoxide and water ; the mixture becomes explosive when the proportion of oxygen to propylene rises to that required by the reaction $C_3H_6 + 3O_2 = 3CO + 3H_2O$. Less heat is developed in this change than would be produced by the combustion of the hydrogen which is also present in the gaseous mixture, and it is suggested that the deciding factor is not the total heat of combustion, but the reaction velocity.

A precisely similar effect is produced by marsh gas, of which 22–24 per cent. suffices to prevent the explosion of a mixture of equivalent quantities of hydrogen and oxygen. Here again the explosion takes place when the proportion of oxygen is sufficient to burn the marsh gas to water and carbon monoxide—$2CH_4 + 3O_2 = 2CO + 4H_2O$. T. M. L.

411. *Lecture Experiments to Illustrate Equilibrium and Dissociation.* **J. Stieglitz.** (Chem. News, 82. pp. 212–213, Nov. 2, 1900. From the Amer. Chem. Journ. 23, No. 5.)—The effect of an excess of one of the decomposition products in repressing dissociation may be shown by sealing up phosphorus trichloride or phosphorus tribromide with bromine, under reduced pressure, using (1) molecular proportions and (2) a large excess of the phosphorus compound. When the tribromide tubes are heated to 80–90°, and the trichloride tubes to 40–55°, the difference of colour is very marked in the two pairs of tubes. The difference in the dissociation constants of PBr_5 and PCl_3Br_2 is shown by the difference in colour at 50° of the two tubes containing molecular proportions of the reagents.

The repression of the dissociation of ammonium hydroxide by an ammonium salt can be shown by adding ammonium chloride solution to one of two beakers of water containing phenol phthalein made bright red by the addition of a little dilute ammonia ; the addition of the ammonium chloride causes the colour to fade to a pale pink. Ammonium chloride may have an acid reaction, but the experiment can also be shown with an ammonium chloride solution that has been made faintly *alkaline* to phenol phthalein by the addition of ammonia. A corresponding experiment is described for the repression of the dissociation of acetic acid by sodium acetate ; the intense red of a methyl orange solution acidified with acetic acid is turned to a reddish brown neutral tint by adding a neutral (or very feebly acid) solution of sodium acetate. T. M. L.

412. *Diagram of Freezing-Point Depressions for Electrolytes.* **J. G. MacGregor.** (Nova Scotian Inst., Trans. 10. pp. 211–234, 1900.)—For solutions, a curve comparable to the curves connecting pv and v for gases can

be obtained by plotting the depression of the freezing-point per equivalent of dissolved substance against the dilution. In the case of electrolytes it is better to use, in place of the dilution, the ionisation coefficient deduced from conductivity measurements. The form of the curves will then depend (1) on the depression constant, (2) on the number of equivalents in the molecule, and (3) the number of ions produced from each molecule; and of these, (2) and (3) may vary with the concentration. Curves of this kind are given for KCl, NaCl, HCl, AmCl, KNO_3, HNO_3, KOH, $BaCl_2$, K_2SO_4, Na_2SO_4, H_2SO_4, Na_2CO_3, $MgSO_4$, and H_3PO_4. The conclusions drawn are: (1) That the curves are compatible with the van't Hoff-Arrhenius theory of the depression of the freezing-point of electrolytes; (2) that all electrolytes have the same depression-constant, the value being 1·85, and the error probably not greater than 0·01; and (3) that in some cases the degree of association and method of dissociation of the dissolved substance can be ascertained from the curves.
T. M. L.

413. *Cryoscopic Researches.* **P. Chroustchoff.** (Comptes Rendus, 131. pp. 883–886, Nov. 26, 1900.)—The depression of the freezing-point is measured by a platinum resistance thermometer, and the concentration of the solution is determined by analysis after the freezing-point has been reached. Values are given for aqueous solutions of sodium chloride, potassium bromide and sulphate, and cane-sugar. Temperature measurements are given to 0·0001°.
T. M. L.

414. *Electrode Potentials.* **W. Nernst.** (Zeitschr. Elektrochem. 7. pp. 253–255; Discussion, pp. 255–257, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—In this paper an account is given of some experiments and calculations by Wilsmore, details of which will shortly be published. The theoretical and practical advantages of the hydrogen electrode as a standard of comparison are emphasised, and a table is given of the potentials of a number of electrodes, some experimentally determined, but chiefly collated from various sources. The p.d. between the hydrogen electrode and Ostwald's calomel electrode is found to be 0·283 volt.

The Discussion, in which **Hittorf, Bredig,** and **W. Nernst** took part, turned on the influence, on the potential, of differences in the chemical behaviour or stage of oxidation of such metals as copper, chromium, and iron.
N. L.

415. *Potential of Silver in Mixtures of Silver Bromide and Sulphocyanide.* **A. Thiel.** (Zeitschr. Elektrochem. 7. pp. 305–307, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The potential of silver in contact with a mixture of slightly soluble silver salts depends on the solubility of the mixture. If the salts are not isomorphous the solubility, and therefore the potential, will be independent of the composition of the mixture. If they form a continuous series of isomorphous mixtures the solubility curve will be continuous, as in the case of silver chloride and silver bromide, but may show a maximum or minimum. If the isomorphism is not complete, the solubility curve will show a horizontal line connecting two curves, and this line may represent either an intermediate solubility or a maximum or minimum. The former type has been found in the case of silver bromide and iodide, and an example of partially miscible salts which show a

horizontal line of maximum solubility is now given in the case of silver bromide and sulphocyanide. T. M. L.

416. *Normal Electrodes and the Absolute Potential of Metals.* **W. Ostwald.** (Zeitschr. Phys. Chem. 35. pp. 333–339, Nov. 2, 1900.)—The use of a hydrogen-electrode as standard in place of calomel and decinormal potassium chloride has the disadvantage that such an electrode is far more troublesome to set up; but the chief disadvantage is that the acid (or alkali) which must be used introduces two ions which differ enormously in their velocity of migration, and so must necessarily set up a potential difference when brought into contact with other solutions; this source of error is a minimum in the case of potassium chloride, the ions of which have almost exactly the same velocity of migration. The hydrogen-electrode has also the disadvantage of a large pressure coefficient (0·029 volt per atmosphere), which would be affected by the vapour pressure of the solution, and the temperature coefficient, though small, is not accurately known. T. M. L.

417. *Conductivities of Solutions of Alkaline Iodates, and the Calculation of Conductivities.* **F. Kohlrausch.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 44. pp. 1002–1008, Nov. 8, 1900.)—Tables embodying the results of very exact measurements of the equivalent conductivities of aqueous solutions of the chlorides, nitrates, and iodates of potassium, sodium, and lithium, from 0·0001 to 0·002-normal. Likewise tables of the mobilities of the six ions, showing their variation (decrease) with increasing concentration. Denoting by α the degree of dissociation as calculated from the conductivities, the author shows that the data are very exactly given by the formula $\frac{1-\alpha}{\alpha^{p}} = \mathrm{B}m^{\frac{1}{2}}$, where m = equivalent concentration, and p and B are constants.

[A very similar suggestion has been already made by Bancroft.]

F. G. D.

418. *Thermic Pressure and the Theory of Solutions.* **G. N. Lewis.** (Zeitschr. Phys. Chem. 35. pp. 343–368, Nov. 2, 1900.)—Thermodynamical arguments are given in support of the equation, $d\mathrm{P}_1/d\mathrm{P}_2 = \sigma_2/\sigma_1$, in which P_1 and P_2 denote the (different) pressures to which two solid or liquid phases of one and the same substance are subjected, these phases being in equilibrium with each other through the medium of another phase; while σ_1 and σ_2 denote the specific volumes. These considerations lead up to the introduction of a function ψ, styled the "Transition-tendency," satisfying the partial differential equation $\frac{\partial\psi}{\partial\mathrm{P}} = k\sigma$.

"Thermic pressure," denoted by β, is defined as the "pressure" on either side of an imaginary plane drawn within the mass of a phase, and the author writes $\beta - \alpha = \mathrm{P}$, where P = external (equilibrium) pressure, and α = the "Attraction-pressure." Considering a system made up of a liquid or solid phase and the corresponding vapour, it is proved from the fundamental equation that the fractional change in the vapour pressure is equal to the change in the external pressure acting on the condensed phase, divided by the pressure which this phase as an ideal gas would exert. Proceeding in this way, the conclusion is drawn that the thermic pressure of a phase is equal to the pressure which it would exert under the same conditions, if it were to behave like an ideal gas, and the proposal is made to measure temperature in the kinetic theory, not by mean kinetic energy but by mean momentum, *i.e.*, by the thermic pressure.

Finally the fundamental theorems of van't Hoff and Raoult are "deduced" from a general theorem concerning "transition-tendencies," and the author's "gas equation," $P = \frac{RT}{v} - a$, where $a = a\,(v_1 T)$ is discussed. F. G. D.

419. *Irregularities of Cadmium Cells.* **W. Jaeger.** (Zeitschr. Instrumentenk. 20. pp. 317–324, Nov., 1900.)—The behaviour of the Weston cell is entirely different from that of the Clark cell, since there is no well-defined transition-temperature, and the e.m.f. of the abnormal cells does not lie along any regular curve. The experiments of the author refer to cells containing a 14·3 per cent. amalgam. Out of thirty-four cells tested at 0°, fourteen showed deviations amounting to less than 0·2 millivolt, and the errors in the remainder ranged quite continuously from + 0·2 to + 1·5 millivolts, one cell only showing a larger error of + 2·3 millivolts. Two of the cells which showed a deviation of + 0·8 and + 1·1 millivolts respectively at 0°, and one normal cell, were tested at temperatures ranging from − 16° to + 40°. The deviation of the normal cell from the e.m.f. calculated by the author's formula was greater than 0·3 millivolt in only one out of thirty-two observations, and that was at a temperature of − 11·5°. The two abnormal cells showed no deviation greater than + 0·3 millivolt when the temperature was between + 10° and + 40°, but varied irregularly below that temperature, the maximum deviation being + 4·49 millivolts at − 16°. It would therefore appear that a Weston cell containing a 14·3 per cent. amalgam which has been standardised at any one temperature can be relied upon at all temperatures between 10° and 30°, but is liable to error below 10°.

These errors are probably due to a change in the amalgam, similar to that which takes place in the concentrated amalgam at ordinary temperatures, and not to a change in the cadmium sulphate. The errors can be eliminated by using a less concentrated amalgam; a 13 per cent. amalgam is now used at the Reichsanstalt, and the cells of the European Weston Electrical Instrument Company, which contain a 12·5 per cent. amalgam, are probably free from error. T. M. L.

420. *Reaction Velocity in Electrolytic Reduction.* **H. Goldschmidt.** (Zeitschr. Elektrochem. 7. pp. 263–266; Discussion, pp. 266–269, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—When an alcoholic, alkaline solution of nitrobenzene is electrolysed, a portion of the liberated hydrogen escapes in the gaseous state at the kathode, whilst the remainder is used in the reduction of the nitrobenzene. If the current is gradually diminished a point is reached when no free hydrogen escapes, and the current is then proportional to the velocity of the reaction. Experiments of this kind made by Malzi and also by the author show that the concentration (C) of the reducible substance and the maximum current (J_m) are connected by the equation $J_m = C_{\frac{2}{3}} \times$ Const. In the method of working above indicated it is necessary to lead a current of hydrogen through the liquid to promote equality of concentration, and since this must be stopped in order to observe the point at which hydrogen ceases to be evolved at the kathode, errors are introduced into the observations. A better method consists in separating the electrodes by a porous cell and measuring the e.m.f. of polarisation for increasing currents. The values thus obtained are plotted out, when a sharp break in the curves indicates the points at which

the evolution of hydrogen ceases. Experiments made in this way with nitrobenzene, the three nitrotoluenes, azobenzene, and azoxybenzene, at 25°, 35°, and 45°, confirm the validity of the law stated above. This result is not in agreement with the researches of Haber, who, however, worked with very low current-densities. The temperature coefficient of electrolytic reduction is very small, a difference of 10° increasing the velocity constant by about a third only. On this point the author is in agreement with Haber and Tafel.

Discussion.—**Löb** suggested the use of a mercury kathode, the maximum current for which no amalgam is formed being taken as a measure of the reaction velocity. **Foerster** referred to the influence on the reduction of different kathode metals, and pointed out the extreme difficulty of ensuring that the general concentration of the electrolyte was identical with that actually obtaining at the kathode. **Nernst** stated that the measurements might have been made more simply and exactly by means of a third electrode; the reaction velocity, moreover, was closely connected with the diffusion velocity of the depolariser. **Bodenstein** said that the difference between the results obtained by Haber [Abstracts Nos. 1332 and 1333 (1900)] and Tafel [Abstract No. 2287 (1900)] was to be referred to diffusion velocities, the latter observer having used substances reducible with difficulty, and the former low current-densities, ample time being in either case afforded for diffusion. N. L.

421. *Electrolytic Separation of Iron and Nickel from Solutions of their Sulphates.* **F. W. Küster.** (Zeitschr. Elektrochem. 7. pp. 257–258; Discussion, pp. 258–259, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The determination of the point at which iron and nickel are electrolytically deposited, either by direct observation or by examination of current curves, is unsatisfactory. The best results were obtained by maintaining a definite kathode potential for five to ten minutes by suitable variation of the e.m.f. of the bath, then immersing the platinum electrodes in hydrochloric acid and observing whether hydrogen was evolved or not. For all the concentrations employed nickel was deposited at a lower potential than iron, the average difference being about 0·1 volt. The influence of concentration is greater in the case of acid than in neutral solutions, whence it is inferred that compounds of the metals with hydrogen, or solid solutions of the metals in hydrogen, are primarily deposited.

Discussion: **Foerster** stated that previous experiments made by himself had yielded similar results. He also pointed out that, as a general rule, metals simultaneously deposited were obtained in a spongy condition, whereas bright, coherent deposits of mixtures or alloys of iron, nickel, and cobalt were as readily obtained as similar deposits of the pure metals. N. L.

422. *Arrangements for Electrolytic Analysis.* **H. Marshall.** (Soc. Chem. Ind., Journ. 19. pp. 992–994, Nov., 1900.)—This is a description of the electrolytic apparatus and equipment in use in the chemical laboratory at Edinburgh University. The resistances, ammeter, voltmeter, &c., are contained in a teak case with glazed front and lid, the working terminals for six experimental circuits being on the outside of the case. A number of diagrams are given in the paper. N. L.

423. *Electrolysis of Dilute Sulphuric Acid Containing Iron.* **K. Elbs.** (Zeitschr. Elektrochem. 7. pp. 261–262; Discussion, pp. 262–263, Nov. 8, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—The adverse influence of iron salts on the useful effect of the

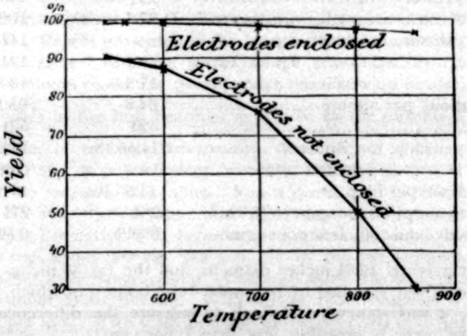
current in the electrolysis of dilute sulphuric acid is well known, but no quantitative data seem to be available. Experiments with two gas voltameters in circuit, one filled with pure, dilute acid, and the other with acid containing known quantities of iron, show that 1 per cent. of iron, using a current density of 2·23 amperes per sq. dm., reduces the volume of gas evolved to 48·3 per cent. of the normal volume, whilst with a current density of 0·228 amperes the loss is 97·4 per cent. With 0·01 per cent. of iron, the loss is 1·7 per cent. for a current density of 2·217 amperes per sq. dm., and 6·3 per cent. for 0·36 ampere. These values were obtained by the use of platinum electrodes, but similar results were obtained with "formed" lead plates; hence it is concluded that the acid used for accumulators should not contain more than 0·01 per cent. of iron. A useful, practical test of the suitability of an acid is afforded by the fact that if no turbidity is produced within a few minutes after neutralisation with ammonia solution, the acid contains at most 0·008 per cent. of iron. N. L.

424. *Electrolysis of Copper Sulphate as a Basis for Acidimetry.* **C. A. Kohn.** (Soc. Chem. Ind., Journ. 19. pp. 962–963, Nov., 1900.)—A convenient quantity of pure copper sulphate is electrolysed in the usual manner, and from the weight of copper obtained the amount of sulphuric acid simultaneously formed is calculated. The solution can thus be used for checking the strength of standard alkaline and acid solutions. The copper sulphate employed must be free from other metals but need not itself be weighed, the accuracy of the process depending simply on the volumetric titrations and the theoretical ratio of copper to sulphuric acid. N. L.

425. *Experiments on the Electrolysis of Fused Salts.* **R. Lorenz.** (Zeitschr. Elektrochem. 7. pp. 277–286; Discussion, pp. 286–287, Nov. 15, 1900. Paper read before the Deutsch. Elektrochem. Gesellschaft at Zürich, Aug., 1900.)—An account is here given of the work done by the author and his various assistants during the last four years in order to arrive at the chief laws underlying the electrolysis of fused metallic halogen compounds. The lecture was accompanied by a series of experiments. Subjects dealt with are current efficiency, determination of polarisation, e.m.f. generated, conductivity, conformity with Faraday's law, and also the action of the finely diffused metals in their respective molten haloid salts, temperatures up to 1,000 C. being considered.

Various forms of apparatus are given and illustrated. A V tube of glass, or porcelain (according to temperature), enclosed in an air bath consisting of an inverted truncated pyramid, with a movable lid, the latter admitting of easy regulation of temperature, is also described. A cylinder, vertically inclined, surrounded by two superimposed circular Fletcher furnaces, the lower one giving access to the flame from a blowpipe through a hole, while the upper one allows the flame to escape to an opening on the opposite side, may also form a suitable arrangement for the purpose of keeping molten salts at a uniform temperature. Two forms of electrically heated furnaces, consisting in the main of carbon cylinders heated by a suitable current, variable at will, and only differing in the manner in which the contacts are made, are explained.

The electrolysis of molten zinc chloride is first considered, and the fact mentioned that there are two kinds of this compound, viz., one which is easily electrolysed, and the other only with difficulty. In the case of the latter, on passing the current, hydrogen only is generated at the kathode, but no zinc, and only a very little chlorine at the anode, and as both electrodes consist of carbons, the anode is appreciably attacked. As the electrolysis proceeds, finely diffused zinc is given off. A current may be passed for hours through an electrolyte of this composition without giving any results. The "easily" electrolysed zinc chloride, obtained by previous treatment of the "bad" variety with an excess of hydrochloric acid and subsequent evaporation and fusion, yields pure chlorine and zinc from the very beginning of the electrolysis. The cause is to be sought in the hydrolysis of $ZnCl_2$, viz., $ZnCl_2 + 2H_2O \rightleftarrows Zn(OH)_2 + 2HCl$. This observation also holds good for the chlorides, bromides, and iodides of a number of other metals forming hygroscopic salts. The next phenomenon dealt with is the diffusion of metals when introduced into their molten chlorides. Lead, for instance, on being fused under a layer of lead chloride in a tube of hard glass, according to the temperature employed, gives off a "fume" of very finely divided lead above the surface of the molten metal, which is at first dissolved by the chloride. After saturation, the latter is rendered turbid and non-transparent, the height of this opaque layer varying directly with the rise of temperature. The "fume" of zinc under such conditions is a beautiful blue, that of cadmium reddish brown, lead dark brown, and silver quite black.



This solution or diffusion of metals in their chlorides, has hitherto been explained by the formation of sub-chlorides. The metal is always first evolved and distributed in this manner before saturation is reached, giving rise to recombination with the haloid evolved, which results in polarisation. This explains why on the passage of small currents, say ½ ampere, no visible electrolysis takes place, and hitherto many of these bodies have, according to their behaviour, been looked upon as metallic conductors (lead chloride). If, however, the electrodes are surrounded by a tube preventing this diffusion of the ions given off, this recombination does not take place with varying temperatures, as will be seen from the curves in the accompanying diagram.

A further deduction drawn from this is, that when the yield is *nil*, there is no counter-e.m.f., and, on the other hand, that with the highest yield there is the maximum of counter-e.m.f. This is proved by passing chlorine gas over molten lead in lead chloride.

A discussion followed the paper. O. J. S

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

426. *Trials of Steam Engines with and without Jackets.* (Mech. Eng. 6. pp. 519–521, Oct. 13, 1900.)—This is an account of a series of trials made by M. Longridge on a mill engine to test the efficiency of jackets. The engines are side by side horizontal, compound, jet-condensing fitted with Corliss valves. Cylinders are jacketed on the barrels and the ends, and a steam coil is fitted in the receiver. Jackets, coil and receiver, are drained by steam traps, as also the steam separator in the main steam pipes. The following are a few of the principal results arrived at:—

	Jackets off.	Jackets on.
Boiler pressure	147 lbs.	148 lbs.
Vacuum	27·1 inches	27·2 inches
Steam pressure in jackets, h.p.	—	147 lbs.
„ „ „ l.p.	—	124 „
„ „ receiver	17·2	16·8 „
Revolutions per minute	64·8	65·1
i.h.p.	524	521
Steam per i.h.p. to cylinders	14·55 lbs.	13·21 lbs.
„ „ jackets	—	0·68 „
Total steam per i.h.p.	14·55 lbs.	13·89 „
Heat consumption of engine in B. Th. U.	284	271
Thermodynamic efficiency of engines	0·568	0·596

The h.p. cylinder is 19·31 inches diameter and the l.p. 38 inches with 4-feet stroke. Steam was supplied by two water-tube boilers, in which, due to the oscillations, it was somewhat difficult to measure the difference of water level, but the error is probably less than 1 per cent,

Combined indicator diagrams plotted from the indicator cards are given.

L. S. R.

427. *High-Speed Reciprocating Engines.* **A. Coats.** (Elect. Engin. 26. pp. 477–479, Oct. 5; 524–526, Oct. 12; and 553–555, Oct. 19, 1900. Paper read before the Glasgow Technical College Scientific Society.)—Early attempts at high-speed engines failed principally on account of insufficient attention being paid to the inertia and the reversal of stress being thought too little of. More careful fitting is also needed and the alignment must be dead true. Various points of details are discussed, among which is the leakage of steam past the piston. This was remedied by putting a brass strip on the inside ring, which is of the Willans pattern, and the result was very marked. The probable cause is that the piston ring was first forced from the cylinder face by water, and then the steam forced its way through.

The influence of the ports which often have to empty and fill the cylinder in one-tenth of a second is very considerable. Loss due to bends is difficult to ascertain, but the Row tube is cited as an instance of how condensation is increased by bent or tortuous surfaces and passages. Ports should be made bell-mouthed. Condensation is largely a question of transference of heat from the steam to the cylinder walls, and is a time function; therefore if speed is increased, initial condensation is proportionally decreased. The question of steam *versus* air buffers is discussed at length, and if the buffer is removed from the influence of the oil bath, steam is preferable.

Alley & McLellan's and the Mirlees Watson & Yaryan Co.'s high-speed engines are fully described. The Reavell engine is dealt with, and the exclusion of the water condensed in the jackets when giving the steam consumption of the engine is alluded to; table of tests is also given. The author then describes an engine designed by himself. The engine is fitted with a steam buffer whose clearance can be altered. The effects of inertia at the various portions of the stroke are also discussed at length, and the bearing of the pressure in the buffer on these is dealt with. The results of some preliminary tests give the consumption as slightly under the Willans engine with a mechanical efficiency of 92 per cent. L. S. R.

AUTOMOBILISM.[1]

428. *Tractive Effort.* **M. G. Forestier.** (Horseless Age, 7. pp. 13–16, Oct. 31, 1900. Report presented to the International Automobile Congress at Paris.)—The various resisting forces which constitute the coefficient of traction on common roads are placed under the following heads: (1) friction of axle spindles in the hub bearings, expressed by the formula $T_f = \phi \frac{F}{D} p$, where $F =$ dia. of spindle, $D =$ exterior diameter of wheel, $p =$ load on spindle (lbs.), and ϕ a coefficient, variable with the nature of the lubrication and the surfaces in contact. For a given type of vehicle, in order to reduce the axle friction, the ratio F/D may be reduced, and also the coefficient ϕ. Formerly, with taper axle spindles and solid lubricant, the value of ϕ was about 200 lbs. per ton, but by the employment of a good liquid lubricant with "demi-patent" (Collinge) axles, the value of ϕ has been reduced to about 20 lbs. per ton. With ball or roller bearings, ϕ varies from 5 to 10 lbs. per ton. With plain bearings an excess of oil must be avoided, as with excess of lubricant the coefficient of friction increases as the square of the speed.

(2) Resistance to translation on the road. This, if the translation is simply rolling, is expressed by $T = (f \pm i) \frac{P}{D}$, where $P =$ total weight of vehicle in tons, $i =$ the inclination expressed in thousandths, and f a coefficient variable with the road surface and the diameter D of the wheels. In practice T also comprises (*a*) the force necessary to overcome the roughnesses of the road, expressed by $P \sqrt{\frac{h}{D}}$, in which $h =$ height of obstacle; (*b*) the resistance due to depressions or holes in the road surface. Dupuit has shown that for two-wheeled vehicles the pull on concave parts of the road is $\theta \sqrt{\frac{1}{1 - \frac{R}{R_1}}}$ where $\theta =$ pull on the level, $R =$ radius of wheel, $R_1 =$ radius of curvature of undulation; and for convex parts of the road the pull is $\theta \sqrt{\frac{1}{1 + \frac{R}{R_1}}}$; (*c*) the resistance due to deformation of the road

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[1] Electric Automobiles are described in the section dealing with Electric Traction.

surface under the weight of the vehicle, which according to Cariolis is expressed by $Tn = \frac{3}{8}\sqrt[3]{\frac{12}{mp} \times \frac{P^4}{D^2}}$, in which m is a coefficient depending on the hardness of the road, and p = width of tyres; (*d*) the resistance due to describing curves, for which, in the absence of methodical experiments, no data can be given.

(3) Losses due to the vibration of the vehicle. The author does not investigate theoretically this source of loss of energy, but the following table, based on experiments with a Panhard and Levassor petrol car with solid rubber tyres, is given as showing the values of the 2nd and 3rd terms of the traction resistance coefficient per ton :—

	Tyres.	
	Rubber.	Steel.
Good macadam, fairly dry	30 lbs.	33 lbs.
Slightly defective macadam, fairly dry	36 „	40 „
Good macadam, wet	40 „	44 „
Slightly defective macadam, wet	44 „	49 „
Unsettled macadam	50 „	55 „

(4) Air resistance, expressed by $T_a = K. S. V^2.$, where S is the surface in sq. metres of vehicle projected on a plane normal to direction of motion; K is a coefficient varying with the nature of the vehicle, assumed to be = 0·0288 for automobiles, and V is the velocity of the vehicle in metres per second. For an area of 1 square metre, and for 1 square yard the following figures are given :—

Speed in km. per hour	6	8	10	12	15	20	25	30	36
Air pressure in kg.	0·079	0·142	0·221	0·317	0·498	0·887	1·387	1·998	2·88
In English measure—									
Miles per hour	3¾	5	6¼	7½	9	12½	15⅝	18	22½
Air pressure in lbs. per sq. yd.	0·145	0·261	0·406	0·580	0·917	1·62	2·55	3·67	5·22

(5) Acceleration, expressed by the term $\frac{P}{g}\frac{dv}{dt}$, which shows the advantage of slow starting and of maintaining uniformity of motion.

Tyres.—Under this head the author considers the question of broad and narrow tyres, and points to cases in which a decrease in breadth of tyre has been made with advantage. The advantages of tangential spoke wheels over wood wheels are also considered.

Suspension.—The following table, from experiments by Dupuit, is given as showing that spring suspension may increase the coefficient of traction :—

	Gravel road.	Paved road.
Cart without springs	60 lbs.	34 lbs.
Spring-suspended public conveyances	60 lbs.	40 lbs.
Private spring-suspended vehicles	72 lbs.	68–74 lbs.

The increase caused by suspension diminishes as the speed increases. In general, however, the reduction, by spring suspension, of loss of motive power due to shocks on rough roads is undoubted. C. R. D'E.

429. *Calculation of Motive Power for Automobiles.* **S. A. Montel.** (Écl. Électr. 24. pp. 393–395, Sept. 8, 1900.)—In an automobile moving on the level, the forces opposing motion are of two kinds, some, such as bearing-friction and the friction of the wheels against the ground, being independent of the speed, and others, such as air-resistance and the resistance produced by shocks due to irregularities of the road being proportional to the square of the speed. Let v be the car's velocity at the moment t when f is the sum of the former forces, and av^2 the sum of the latter forces. Then the total force opposing motion is $f + av^2$. If the road is not level, we must also consider another force f' which is the component of the car's weight parallel to the ground. The total force F opposing motion is then—

$$F = f + av^2 \pm f' \qquad (1)$$

Considering only those cases where F is opposed to the car's motion (*i.e.*, if downhill, f' must be $< f + av^2$), if p is the total weight of the car and g is the acceleration due to gravity, then at every instant

$$\frac{p}{g} \cdot \frac{dv}{dt} + F = 0 \qquad (2)$$

where $\frac{dv}{dt}$ is the fall in speed in unit time due to the force F. To find F, we deduce from (1) and (2) that

$$-\frac{p}{g\sqrt{a(f \pm f')}} \cdot \frac{d\left(v\sqrt{\frac{a}{f \pm f'}}\right)}{1 + \frac{a}{f \pm f'}v^2} = dt,$$

whence by integration, and remembering that when $t = 0$, $v = V$, the speed of the car at the moment when power is cut off, and also that at a certain time t_0, $v = 0$, we get—

$$\tan^{-1} \frac{V}{\sqrt{f \pm f'}} \sqrt{a} = \frac{gt_0\sqrt{f \pm f'}}{p} \sqrt{a} \qquad (6)$$

Now t_0 and V can be readily observed : hence this equation gives us a relation between $f \pm f'$ and a, and if we can find the former, we can obtain a by successive approximations. For low or moderate speeds, av^2 is negligible compared to f or $f + f'$, but possibly not to $f - f'$. Assuming that av^2 is negligible, we can by integration find that

$$v = V' - \frac{g}{p}(f \pm f')t \qquad (8)$$

where V′ is the speed (not great) at time $t = 0$ when power is cut off. Remembering that after a time t', $v = 0$, we find from (8) that

$$f \pm f' = \frac{V'}{t'} \frac{p}{g} \qquad (9)$$

whence we can determine $f \pm f'$. In view of our assumptions, this determination will be more accurate the less the gradient of the road. If we make two trials in the uphill direction, in the first cutting off the power when the speed has a high value V, and in the second when the speed is low, V_1, and two similar trials in the downhill direction, then by equations (6) and (9) we can find f, f', and a. Having found these, the power W required by the car is given by $W = FV$. For the trials, the route should be straight, evenly graded and smooth. E. H. C.-H.

430. *Gillet-Forest Petrol Car.* **P. Sarrey.** (Locomotion Automobile, 7. pp. 690–693, Oct. 25, 1900.)—A single-cylinder, horizontal motor is placed in the front of a tubular underframe, which carries the driving mechanism and the body, and which is suspended by springs upon the front and rear axles. The motor develops 5 h.p. at 800 r.p.m., but its speed can be varied from 100 to 1,200 revolutions and its power from 2 to 7 h.p. The diameter of the piston is 120 mm., and its stroke is 140 mm. The crank-shaft, the cam-shaft, the centrifugal governor, and a pair of bevel wheels (which transmit the power from the motor) are all enclosed in an aluminium crank-chamber. The governor varies the position of a special exhaust cam upon the cam-shaft; this cam is so shaped that the extent to which, and the moments at which, it operates the exhaust valve depend upon its longitudinal position on the shaft. When it is desired to depart from the normal engine speed, the cam-operated lever is moved by hand longitudinally relatively to the cam, but the action of the governor upon the cam is not interfered with. Electric ignition is fitted and provision is also made for the use of a lamp-heated tube. The cylinder and the valves are water jacketed. The cooling water circulates without the aid of any pump through a radiator in front of the car; a constant-level device is used for regulating the flow of water, and it is said that 6 litres is sufficient for a run of 300 km. The power is transmitted to a differential gear, in the centre of the "live" rear axle, through a friction clutch and a change-speed gear, both of which are fixed to the underframe, and through a universally jointed shaft to a pair of bevel wheels inside the differential gear-case. The change-speed gear is of the toothed-wheel type and provides three speeds (9, 18, and 32 km. per hour) forward, and one speed (6 km.) backwards; of the forward speeds two are thrown in and out of use by sliding the driving gear-wheels in and out of mesh with the corresponding wheels on the driven shaft; the gear-wheels forming the third speed are always in mesh with one another, but that on the driving shaft is mounted freely and can be clutched to its shaft by sliding the second speed gear-wheel into engagement with it. Three band brakes are provided; two of these act upon the hubs of the rear wheels and the third is fitted upon the universally jointed transmission shaft. Wheel steering, in which a quadrant and a toothed-wheel connect the inclined steering pillar to the front wheels, is employed. All four wheels are made of wood, are fitted with pneumatic tyres, and are 80 cm. in diameter. A. G. N.

431. *Delahaye 14-H.P. Petrol Car.* (Locomotion Automobile, 7. pp. 722–724, Nov. 8, 1900.)—This vehicle differs considerably in design from the 7 and the 9½ h.p. carriages previously made by this firm. The motor, which is fixed horizontally at the back of the underframe, is not only larger than those hitherto employed, but its two cylinders are fitted with variable-timing electric ignition, and with small compression-relieving exhaust cams which are so arranged that they come into operation when starting the motor and when setting the ignition device to its latest position. A plan of the underframe is given in the article, and this shows the general arrangement of the mechanisms. The power is transmitted from the crank-shaft, at the back of the car, to the change-speed gear, in the centre of the frame, by means of a single belt which is normally held by a spring upon a loose pulley, but which can be moved by the driver on to a fast pulley. The change-speed gear is of the toothed-wheel type in which the wheels on the first motion shaft can be moved into mesh with those fixed upon the differential gear counter-shaft. Side chains transmit the power from this counter-shaft to each of the rear driving wheels. Three forward and one reverse gears are provided. A. G. N.

432. *Buchet 6-H.P. Petrol Motor.* **R. Delevoye.** (Locomotion Automobile, 7. pp. 724–725, Nov. 8, 1900.)—A description, with sectional drawing, of a single-cylinder, water-jacketed petrol motor in which the exhaust valve is placed centrally in the cylinder head. The admission valve also opens direct into the combustion chamber. The cylinder bore and stroke are both 100 mm. Owing to the absence of resistance to the entrance of the explosive mixture and to the exit of the exhaust gases, the power developed by the motor at high speeds is considerably increased. Three tests gave the following results: 6·72 b.h.p. at 1,600 r.p.m., 6·78 b.h.p. at 1,804 revs., and 7·2 b.h.p. at 1,972 revs. A comparison of the specific displacement of this motor with that of other well-known types is given as follows: De Dion 1¾ h.p., 66 mm. bore × 70 mm. stroke, 11·8 litres per poucelet, giving 118 kg.m.-second; De Dion 2¼ h.p., 70 × 70, 11·6 litres, per poucelet, giving 130 kg.m.-second; Buchet 6 h.p., 100 × 100, 9·53 litres per poucelet, giving 510 kg.m.-second; Panhard 6 h.p., 9·2 litres per poucelet, giving 490 kg.m.-second; Pengeot 6 h.p., 10·3 litres per poucelet, giving 530 kg.m.-second. The last two are slower speed motors, having greater expansion. Buchet is building similar motors of 12 and 24 h.p.; the smaller size above described weighs under 50 kg. A. G. N.

433. *Remington Motor and Carburettor.* (Horseless Age, 7. pp. 12–13, Oct. 10, 1900.)—This article describes a gasolene motor in which four horizontal cylinders are arranged in pairs opposite to one another on either side of a common crank case. Each cylinder has two pistons, the movements of which are so arranged that at the completion of the exhaust stroke the pistons approach one another very closely, so that all the products of combustion are expelled. The firing of the charge in the cylinder is effected by means of an external flame and timing valve. The cylinders of an engine developing from 8 to 10 b.h.p. at 300 to 500 r.p.m. are 4½-inch bore × 4½-inch stroke, the weight of the complete engine being 300 lbs.

The carburettor is of a very simple form, in which air passes ever the surface of a wick which is kept saturated with petrol, the surface exposed to the air being variable. Illustrations of the engine and carburettor are given. C. R. D'E.

434. *Cunningham Steam Truck.* (Horseless Age, 7. pp. 11–16, Oct. 3, 1900.)—This article describes and illustrates a form of heavy steam lorry now being manufactured by the Cunningham Engineering Co., of Boston, Mass. The general design consists of a platform with a cab in front containing the boiler and seats for driver and attendant, who have an unobstructed view ahead. The engines and driving gear are carried below the platform. All four wheels are drivers, steering being effected by a movement of the front axle upon a pivot and locking plate. Wood wheels with iron tyres are employed, equal diameter front and back. In the 3-ton lorry, 66 square feet of platform area, exclusive of cab, are provided; the wheel base is 9 ft. 8 in., and gauge 4 ft. 6 in.

The boiler is of the watertube type, with 120 square feet of heating, and 3 square feet of grate area; either coke or liquid fuel may be employed.

Each lorry has two compound engines, cylinders 3½ inches and 5 inches diameter by 5 inches stroke, speed 300 r.p.m. The engines are designed for 200 lbs. steam pressure, and arrangements are made for admitting high pressure steam into the l.p. cylinders; they are placed on either side below the platform and have a common crank-shaft on which are two spur pinions, each of which gears with two spur wheels, which drive through hydraulic clutches and pitch-chain gears to spur pinions on short spindles above either axle. These pinions engage with spur-wheel rings on the exterior of each differential gear, the power being thence transmitted through divided axles to the road wheels. A gimbal joint between the toothed ring and the case of the front axle differential permits the turning of the axle for steering purposes. Details are given of the hydraulic clutches and the brake gear acting on the exterior of these, but no practical results of performances of these vehicles are stated. C. R. D'E.

435. *Turgan Steam Omnibus.* (Locomotion Automobile, 7. pp. 738–740, Nov. 15, 1900.)—A brief description, with drawings of the steam generator and rough drawings indicating the general arrangement of parts. The vehicle is intended for carrying twenty passengers any distance. The driving mechanism is placed in front and consists of an upright tubular boiler and a pair of 20-h.p. compound engines. The boiler weighs 680 kg. and measures 1·20 m. × 0·80 m. × 1·20 m. high; it will generate 435 kg. of steam (at 15 kg. pressure) per hour, or 580 kg. with forced draught, and consumes 1 kg. of coal per 6 kg. of steam. The engines weigh 8 kg. per h.p., and are fitted with cylinders of 90 mm. and 170 mm. diameter by 130 mm. stroke; their normal speed is 600 r.p.m., and they are each coupled by a single chain to one of the rear wheels of the vehicle. Provision is made for admitting high-pressure steam into the low-pressure cylinders when necessary. Two independent feed pumps supply water to the boiler. A condenser is placed on the roof, and it normally prevents loss of water when travelling. The weight of the vehicle is 3,250 kg., and its maximum speed is about 22 km. per hour. The conclusions drawn from tests made with it are that an omnibus, weighing about 5 tons loaded, can commercially carry sixteen to twenty passengers over rough and hilly roads at an average speed of 15 km. per hour, and with a fuel consumption of 3 kg. of coal per km.

A. G. N.

REFERENCES.

436. *Balancing of Engines.* **J. Macfarlane Gray.** (Mech. Eng. 6. pp. 168–171, Aug. 4; and 198–200, Aug. 11, 1900. Paper read before the Institution of Marine Engineers, May 14, 1900.)—An investigation dealing generally with the elements of the subject. H. R. C.

437. *French Trials of Alcohol for Automobiles.* (Automotor Journal, 5. pp. 72–73, Nov., 1900.)

GENERAL ELECTRICAL ENGINEERING.

438. *Transportable Electricity.* **W. A. T. Müller.** (Centralblatt f. Accumulatoren- u. Elemententk. 1. pp. 149–150, April 15; and 164–166, May 1, 1900.)—A zinc lead-peroxide battery invented by Burgwall and Ofenschüssl is described in which the electrolyte is contained in a concentrated form in the pores of the peroxide plate so that when placed in water an electrolyte of the normal density is obtained. The peroxide plates are of the grid type, and are pasted with litharge mixed with alum which has been treated with a solution of caustic potash so as to form a plastic mass. Very hard and porous plates are so obtained which are also suitable for the manufacture of accumulators. The dried plates are immersed in concentrated sulphuric acid. To prevent absorption of moisture from the atmosphere the prepared plates are coated with potassium silicate. They may then be kept for a year without change. The negatives are zinc plates from 1·5 to 3·0 mm. thick, according to their size. The cell is charged by the addition of water. Curves are given showing that the e.m.f. on discharge remains for a long period about 2·3 volts. Each kilogram of the complete battery will give 30 watt hours. The zinc used is 60 grm. per hecto-watt hour. Plans are given of the arrangement of an automobile battery with celluloid boxes. The battery consists of 12 cells, and is designed to give 45 amperes at 27 volts. The working cost is stated to be from 1·2 to 1·5 marks per kilowatt hour.

W. W. H. G.

439. *Prediction of Capacity of Accumulators.* **C. A. Rossander** and **E. A. Forsberg.** (Elektrotechn. Zeitschr. 21. pp. 881–883, Oct. 25, 1900.)—This is a mathematical calculation for determining the requisite capacity of a battery that is discharged at various rates. It is based on the formula—

$$T \, . \, J^{1 \cdot 4} = \text{constant}$$

where T is time of discharge and J the current during discharge. The value of—

$$\frac{it}{c} = \epsilon$$

where i is the current, t the time of discharge, and c the capacity for this particular rate of discharge, which may be called the *discharge factor*, is calculated from the formula—

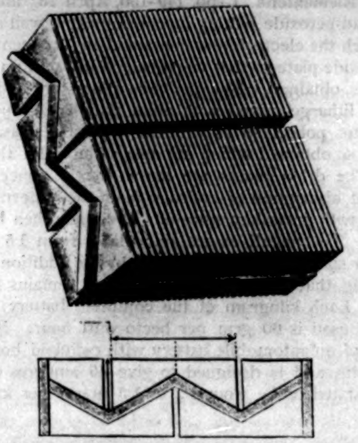
$$\epsilon = \frac{(a + bT)^{2+v} - a^{2+v}}{Kb\,(2 + v)}$$

where the current increase is supposed to follow a linear law $a + bT$, $v = 0 \cdot 4$, and K is a constant. With the help of this formula the various discharge factors can be estimated and their sum will give the whole discharge. A graphical method is also described.

W. W. H. G.

440. *Omega Accumulator Plate.* **P. Weber.** (Centralblatt f. Accumulatoren- u. Elementenk. 1. pp. 343–344, Oct. 15, 1900.)—A type of battery plate denoted "Omega," invented by Geoffroy and Delore, of Clichy, near

Paris, and manufactured in Germany by the Berliner Accumulatoren und Elektricitäts Gesellschaft, is described. The plate (see Fig.) has deep grooves and is provided with channels, so that from the end view it appears zigzag or wave form. This shape gives a working surface seventeen times greater than the projected surface, and a good circulation of the electrolyte is maintained. A plate with the dimensions 22 cm. broad, 27 cm. high, and 1·4 cm. thick, weighs 5 kg. Tests made in the Paris Laboratoire Central d'Electricité with such a positive plate between two negatives gave a capacity of 30–32·9 ampere-hours. Further measurements with a discharge of 100 amperes gave a capacity of 25 ampere-hours, the final voltage in each case being 1·7 volts. The capacity for a three hours' discharge was 54 ampere-hours.



W. W. H. G.

441. *Porcelain Manufacture.* **J. Herzog** and **C. Feldmann.** (Elektrotechn. Zeitschr. 21. pp. 905–912, Nov. 1, 1900.)—The manufacture of porcelain is considered in particular relation to articles used for electrical purposes. Some details of the materials and their geographical distribution are given, together with notes on the extent of contraction which porcelain articles undergo in the process of firing. The contraction and loss of weight has to be anticipated in the moulding, and may amount to from 15 to 18 per cent. It has generally different contraction coefficients in length, breadth, and height, respectively. The glazing substance has to be selected of similar contraction-coefficient to the porcelain upon which it is to be placed. Errors in this selection result in one or other of two kinds of defects in the glazing, which are developed in subsequent changes of temperature. In both cases the glazed surface is broken, but the edges of the sutures may be either forced up by pressure against one another, or they may be separated. Moisture intrudes through these sutures in either case, and such porcelain is unsatisfactory for insulators. As an example of the methods adopted in forming various shapes and of firing porcelain articles, the manufacture of a land-line insulator is dealt with in detail.

R. A.

442. *Eddy Current Loss in Iron Tubes and Armouring.* **C. Feldmann** and **J. Herzog.** (Elektrotechn. Zeitschr. 21. pp. 861-868, Oct. 18, 1900.)—When an iron tube surrounds a conductor through which alternating currents are passed, eddy currents are induced whose magnitude and effect are calculated. The eddy current loss W_f is given as—

$$W_f = \frac{M\sigma J^2}{1000 a d^2} f l\, 10^{-7} \text{ watts},$$

where—
σ = specific resistance of the iron in c.g.s. units.
J = effective current in amperes in conductor.
a = half the thickness of the wall of the tube in cm.
d = mean diameter of the tube in cm.
l = its length in cm.
f = its cross section in sq. cm.

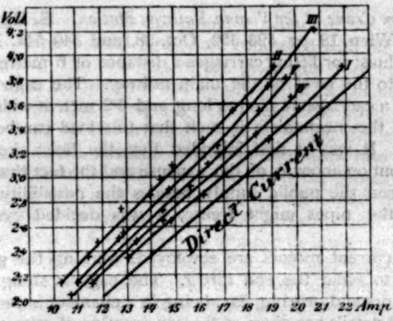
whilst—

$$M = 2\pi \sqrt{\frac{\mu \sim}{\sigma}}.$$

μ being the permeability for average induction and $\sim$ the frequency.

A graphical construction is given to find the connection between the currents and the e.m.f.'s involved, and practical cases are considered.

The article concludes with the description of an experimental investigation made in the laboratory of the Helios Company to find the apparent resistance at 50 $\sim$ of a German silver wire of 0·168 ohms. The wire, 2 metres long, had glass beads strung on it, and was placed in various iron tubes. The following results were obtained :—



No. of Tube.	Diameter of Tubes in mm. Outer.	Inner.	4a in mm.	Apparent Resistance in ohms.
I	13·5	9·5	4	0·205
II	16·0	11·0	5	0·200
III	26·0	19·5	7	0·190
IV	33·0	25·0	8	0·186
V	59·6	51·3	8·3	0·180

The results with different currents and pressures are shown in the accompanying diagram.

W. W. H. G.

443. *Electric Elevator Control.* **H. Cochrane.** (Amer. Electn. 12. pp. 522–525, Nov., 1900. Abstract of a paper read before the Chicago Electrical Association.)—In the system here described, the motor is compound wound with the series coil divided into sections, and the controller is arranged first to short-circuit, step by step, a resistance in series with the armature; and then to short-circuit, step by step, the sections of the series coil on the motor field magnet. In order to prevent racing, the following automatic arrangement is employed, viz.: A stationary solenoid, in series with the shunt field coils of the motor, is arranged to act on an electromagnet which is in the armature circuit and is mounted on a longitudinally movable bar controlled by a spring. This bar bears contact pieces arranged on an insulating support and adapted to engage successively with a series of fixed brushes connected to the sections of the series field coils of the motor. When the motor commences to be driven as a dynamo by the load, the current reverses in the movable electromagnet and causes it to move against its spring so as to cut out, one by one, the series coils on the motor field magnet. If the current generated by the motor still increases, the sliding switch cuts the series winding into circuit again, but in the reverse direction, so that it strengthens the field of the motor and reduces its speed. An electromagnetic device is also described for actuating the controller from a switch in the elevator car, and also an elevator mechanism similar to Fraser's [see Abstract No. 1078 (1899)]. Diagrams of the connections and elevator mechanism are given in the original paper. C. K. F.

444. *Electric Crane at the Vienna Railway Station.* **E. Egger.** (Zeitschr. Elektrotechn., Wien, 18. pp. 526–532, Oct. 28, and 540–544, Nov. 4, 1900.)—This is a large hoist for lifting carriages a distance of 6 metres from the City Railway level to the level of the main railway. The cage or car is large enough to take a carriage 14 metres long and 3·2 metres wide, and weighing 30,000 kg., and the mechanism is such that this load can be lifted 6 metres in 1¾ minutes. It was at first intended that the hoist should be worked hydraulically, but on account of the expense and the fact that electric power was available from the public supply, besides the possibility that if worked hydraulically the pipes might freeze, it was decided eventually to use electricity.

Continuous-current motors are employed, working the gearing through double worms to avoid the end thrust. The cage is slung by heavy link chains, the motors and gearing, &c., being in a chamber immediately over the cage race. Full details are given of the construction of cage, and the gearing, switch gear, &c. The paper is illustrated by twelve figures, eight of them being line drawings. E. K. S.

REFERENCE.

445. *High-pressure Switches and Fuses.* **W. E. Warrilow.** (Elect. Engin. 26. pp. 189–190, Aug. 10; 224–229, Aug. 17; 274–276, Aug. 24; 307–310, Aug. 31; 371–374, Sept. 14; 417–419, Sept. 21; 488–492, Oct. 5; and 510–511, Oct. 12, 1900.)—A series of articles illustrated by drawings, describing the switches and fuses of several well-known makers.

GENERATORS, MOTORS, AND TRANSFORMERS.

446. *Magnetic Attraction in Dynamo Design.* **B. A. Behrend.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 599–608, Nov., 1900.)—In large motors or generators with small clearance, tremendous mechanical effects are caused by the magnetic forces, and it is of the greatest importance when designing them to be able to calculate the forces called into play when the axes of the armature and field are not in exact coincidence. The ordinary formulæ which are obtained on the supposition of two parallel magnetic planes facing one another are given and discussed, and it is shown that they are of little practical use. The author considers the problem of the magnetic forces between two cylinders one inside the other with their axes parallel but not quite coincident. He deduces the following formula for the resultant force, which he says is a most useful and important one :—

$$F = \frac{1}{4\pi} S B^2 \frac{d_2 - d_1}{d_2 + d_1}$$

F is the resultant force in dynes, S the curved surface of the inner cylinder in square centimetres, B the induction, d_2 the greatest and d_1 the least value of the air-gap.

Experiments made on a 300-h.p. inductor generator for 2,000 volts are described, and the experimental figures are compared with the figures given by the above formula. The bearings of the generator were opened and the field was excited while the inductor was standing still. At 18 amperes' excitation the inductor, with shaft weighing 8,400 kgs., was lifted up from the bearings until it clung to the armature frame. When the excitation was lowered to 8 amperes the inductor and shaft fell back into the bearings. Now at 18 amperes' excitation and a frequency of 50, the generator gave 1,400 volts on open circuit, and at 8 amperes it gave 640 volts. From which it follows that $B = 5{,}900$ at 18 amperes and 2,700 at 8 amperes. But in the experiment the magnetism at 8 amperes was attained by lowering the excitation, and as in inductor machines the descending curve of magnetisation often lies 20 per cent. above the ascending curve, the author assumes that when the current was 8 amperes B was 3,100. Now $S = 9{,}350$ cm.², $d_2 = 0·46$ cm., $d_1 = 0·26$ cm. Substituting in the formula we get $F = 7{,}400$ kg. when B is 5,900 c.g.s. In the second experiment $d_2 = 0·72$, $d_1 = 0$, $B = 3{,}100$, hence F is 7,840 kg. The observed value was of course 8,400 kg. Considering the many sources of error, the agreement is fairly satisfactory. A. R.

447. *Calculation of Air-gap Ampere-turns for Toothed-core Armatures.* **W. Sander.** (Zeitschr. Elektrotechn., Wien, 18. pp. 562–564, Nov. 18, 1900.)—The author's method is based on the assumption that the tops of the teeth and the sides and bottoms of the slots constitute an equipotential surface. He draws a diagram showing the approximate shape of the lines which pass from the polar surface into the top and flanks of a tooth and the bottom of a slot. The induction at any point on the surface of the core is taken to be inversely proportional to the length of the line passing through that point. From the diagram of lines the average length of a line for the top of a tooth, its flank, and the bottom of the slot respectively, may be ascertained graphically.

Further, since the areas of the tops of the teeth under cover of the pole-piece, and of the flanks of the teeth and bottoms of the slots are known, the ratios of the total fluxes entering the tops of the teeth, their flanks, and the bottoms of the slots are known. But the sum of these three fluxes is known, since it represents the total magnetic flux entering the armature. Hence the average induction along any one of the three paths may be determined, and when multiplied by the length of path gives the required difference of magnetic potential. A. H.

448. *Iron Losses in Generators.* **G. Dettmar.** (Elektrotechn. Zeitschr. 21. pp. 944–948, Nov. 15, 1900.)—The actual iron losses occurring in a generator are known to exceed, in most cases, by 150 to 200 per cent., but sometimes by as much as 350 per cent., the calculated losses. This large divergence has hitherto been regarded as mainly due to eddy currents produced by the tooling of the core-discs after they have been assembled. The author points out that the true explanation of the effect is to be looked for in the losses taking place in the pole-pieces ; he further criticises the commonly adopted method of calculating the core losses, which is based on taking for the maximum value of the induction the quotient of the flux by the cross-section of the core. Such a value of the induction is only correct for the inner portions of the core ; the outer portion, lying immediately below the teeth, is as a rule subject to a much higher value of the induction, and this fact should be taken into account. The author divides the core into a series of concentric rings, and by drawing a diagram giving approximately the distribution of the lines, determines the mean value of the maximum induction in each ring. The hysteresis loss is then calculated for each ring, and the results added together. By comparing the results obtained by the use of this method with those of the ordinary method, the author finds that the former exceed the latter by some 50 per cent. Dealing with the loss in the pole-pieces, he describes some experiments in which the distribution of the lines over the pole-face was studied by means of iron-filings pictures, the filings arranging themselves in a series of parallel strips corresponding to the regions of the pole-face opposite the teeth of the core. The pictures so obtained are applied by the author to determine approximately the depth of the layer in the pole-piece throughout which the induction is not uniformly distributed. The author points out the importance of eddy-currents in producing a screening action, but makes no attempt to establish a formula for the total loss occurring in the pole-pieces. A. H.

449. *A Belgian Steam Alternator.* (Écl. Électr. 25. pp. 249–258, Nov. 17, 1900.)—This set was exhibited at the Paris Exhibition by Van der Kerchove, who supplied the engine, and the Compagnie Internationale of Liège, the makers of the alternator. The engine is horizontal tandem compound, with cylinders 63 cm. and 109 cm. diameter, stroke 120 cm., speed 100 r.p.m. The normal i.h.p. is 1,000, with a pressure of 9 kg. per sq. cm. and cut-off at 0·2; the h.p. rising to 1,800 when the cut-off is at 0·6. There is a vertical piston valve at each end of each cylinder, these valves being so designed that they act as steam separators, while the exhaust permits the escape of any water condensed in the cylinder. Also the clearance space is very small, the friction and wear are low, and the valves are equilibrated at all pressures. The dashpot, which comes into action after the closing of the port, is of the simplest construction, and suffices for all conditions without readjustment.

The governor acts either on both cylinders or on the high-pressure cylinder only.

The magnet flywheel of the alternator weighs 39 tons, and is made in four pieces. Its diameter overall is 5·5 metres. There are 72 poles, each wound with 105 turns in five layers; the windings are connected in two sets in parallel, each of 36 in series, the resistance being 0·5 ohm. The carcase of the external armature is cast in four parts which are bolted together. Each casting forms half of one side, and the armature sheets are fixed by bolts between the two sides. The air-gap measures 8·5 mm. There are six slots per pole. Each armature coil has five turns of 32 sq. mm. section, and is tested with a pressure 3,000 volts above the working pressure. All the coils of each phase are in series, and the three circuits are star-connected. The resistance of each circuit is 0·125 ohm. The total weight of the armature is 20,500 kg. The exciter armature is on the main shaft, and the eight-pole magnets are compactly mounted on the stator. Its power is 23 kw. at 110 volts.

The exciting current for 2,200 volts on open circuit is 110 amperes. On short circuit the full load of 262 amperes is obtained with an excitation of 75 amperes. With a power-factor of 0·85, the excitation at full load is estimated to be 160 amperes, and the pressure drop 11 per cent. W. H. E.

450. *Steam Alternator by Sulzer and Brown-Boveri.* (Écl. Électr. 25. pp. 289–306, Nov. 24, 1900.)—This 1,760 kw. set was shown at the Paris Exhibition. The engine has triple expansion, with four cylinders, two being low pressure. The diameters of the cylinders are 60, 85, and 102·5 cm.; stroke, 150 cm.; speed, 80 r.p.m.; steam pressure, 11 kg. per sq. cm. [154 lbs. per sq. in.]. The normal power is 1,700 h.p., with cut-off at 0·3, and 1,950 with cut-off at 0·4. Each of the two low-pressure cylinders is in tandem with one of the others. The governor controls the position of the eccentrics actuating the admission valves of the high-pressure cylinder. The admission of the other three cylinders is regulated by hand, as well as the four exhausts.

The alternator is a three-phase machine giving 170 amperes per phase at 3,460 volts, or 6,000 volts between terminals. Its internal rotating magnet has 72 poles, and measures 6·9 metres in diameter overall. Each pole has 45 turns, and the resistance of the 76 coils in series is 0·33 ohm. The armature carcase is supported by two sets of radial arms, giving great rigidity with moderate weight, and admitting of rotation of the armature for inspection or repair. It is made in two halves, which hold the core plates between them by bolts passing through the plates. There are six holes per pole and 36 coils per phase, with twelve turns per coil. The air-gap measures 1 c.m. Excitation is supplied by a 25 kw. four-pole dynamo giving 110 volts, and driven by a separate vertical engine running at 300 r.p.m. The exciting current, on open circuit, is 176 amperes for 6,000 volts; on short circuit 60 amperes of excitation give 170 amperes per phase. On full load of 1,760 kw. with a power-factor of 1 the exciting current is 193 amperes; with a power-factor of 0·85 for an effective load of 1,500 kw. the current required is 231 amperes, and at no load the rise in pressure is 11·5 per cent.

Another alternator by Brown-Boveri is driven by an engine made by Bromley, of Moscow. This 250 kw. alternator has an external rotary field as usually employed by Brown-Boveri when the power of the machine is not too great and when the engine is suitable. With this arrangement the magnetic effect between magnet and armature is opposed by centrifugal force. The internal diameter of the field is 3·60 cm., and the polar width 30 cm. The gap measures 5 mm. W. H. E.

451. *Theory of Synchronous Motors.* **Colard.** (Assoc. Ing. El. Liège, Bull. 11. pp. 346–384, Sept. 30, 1900.)—If V = terminal p.d., assumed constant; ρ = impedance of motor armature (also assumed constant); $\tan\gamma$ = resistance/reactance; p = torque-producing power; e = e.m.f. of motor and I = current; then, putting—

$$\frac{e}{V} = \sqrt{x}, \quad \frac{I\rho}{V} = \sqrt{y}; \quad \frac{2p\rho}{V^2} = z,$$

the author establishes the equation—

$$1 - x - y = z \,.\, \sin\gamma \pm \cos\gamma \sqrt{4xy - z^2}.$$

This equation represents an elliptic paraboloid whose sections by a series of planes parallel to the x-y plane give the power ellipses. The extreme values of x or y corresponding to a given value of z are given by—

$$\frac{1 - z\sin\gamma \pm \sqrt{1 - 2z\sin\gamma}}{2\sin^2\gamma}.$$

The maximum power corresponds to $x = y = \dfrac{1}{4\sin^2\gamma}$; $z = \dfrac{1}{2\sin\gamma}$. The points on the ellipses of power for which y is a maximum or a minimum lie on the parabola—

$$x = 1 + y - 2\sin\gamma \,.\, \sqrt{y},$$

and those for which x is a maximum or a minimum on the parabola—

$$y = 1 + x - 2\sin\gamma \,.\, \sqrt{x}.$$

The method used by the author, in which the x-coordinate is proportional to the square of the motor e.m.f., the y-coordinate to the square of the current, and the z-coordinate to the power, enables us to study graphically the behaviour of a synchronous motor without the necessity of using quartic curves such as those employed by Steinmetz. A. H.

452. *Core Loss in Three-phase Transformers with Unsymmetrical Magnetic Circuits.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 21. pp. 991–992, Nov. 29, 1900.)—On account of the difference in the magnetic reluctances of the paths in a three-phase transformer whose core is asymmetrical, the open-circuit losses for the three phases are not identical. Imagine three straight laminated cores, I, II, and III, laid parallel to each other and united top and bottom by common yokes. At first sight, one would expect the core-loss in II to be less than that in I or III, and these two latter to be equal to one another. Wattmeter measurements show that the loss in II is really less than that in either I or III, but that the last two are *unequal.* In explaining this effect by means of vector diagrams, the author first considers an ideal transformer with no hysteresis loss, and finds that the current in II is exactly in quadrature with the p.d. (copper loss negligible), the current in I lags by say $90° + a$, and that in III by $90° - a$, behind the p.d. in each case. Hence, although the *algebraical* sum of the three wattmeter readings is zero, yet the readings do not vanish separately. The circuit I acts as a source, receiving energy from III, which acts as a sink. By reversing any two of the connections, this action is reversed. When there is a hysteresis loss, this is simply superposed on the results obtained with the ideal transformer, and thus the actual behaviour of the transformer is explained. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

453. *Calculation of Distributing Networks.* **Buffa.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 384–399, Sept. 30, 1900.)—The author develops a method for calculating the distribution of currents in a given network which presents the advantage over the method of Herzog and Stark that by means of a supplementary equation it becomes possible to ascertain, at any stage in the process of solving the linear equations, whether an error has been committed, and if so, to trace the error. A. H.

454. *Copper Saving in Power Transmission.* **F. Spielmann.** (Elektrotechn. Zeitschr. 21. p. 1007, Nov. 29, 1900.)—Referring to Bedell's paper on this subject [see Abstract No. 2499 (1900)], the author states that he regards the simultaneous transmission of a continuous and an alternating current along the same line, and their subsequent separate utilisation in independent circuits connected to the far end of the line, as impossible. He further criticises some editorial comments on Bedell's paper. A. H.

455. *Effect of Wave Form on Capacity Current.* **F. G. Baum.** (Elect. World and Engineer, 36. pp. 610–611, Oct. 20, 1900.)—When the applied e.m.f. wave is a sine curve the effective capacity current (C) is given by the equation—

$$C = 2\pi VKf,$$

where V, K and f are the volts, farads and frequency respectively. This formula is not true for waves of other shapes. For example for a triangular wave the formula is—

$$C = 4\sqrt{3}VKf,$$

showing that the current is 10 per cent. greater than that given by the sine curve formula. If, however, the half-wave be everywhere concave to the axis, *i.e.*, if it have only one *maximum* value (E), then it is safe to use the sine curve formula in practice. If C′ be the average current passing in and out of the condenser then a little consideration will show that $C' = 4EKf$. Since $C = \frac{\pi}{2\sqrt{2}}C'$ for a sine wave, we easily deduce the ordinary formula. The author concludes by pointing out the importance of not having "jagged" waves on long power transmission lines as these waves may increase the capacity current 200 or 300 per cent. A. R.

456. *Periodicity of Alternating Currents.* **J. M. Andrews.** (Journal of Electricity, S. F. 10. pp. 57–59, Sept., 1900. Abstract of a paper read before the Ohio Electric Light Association, Toledo, Aug. 15, 1900.)—A comparison is made of the advantages and disadvantages of the various frequencies in use. For ordinary purposes sixty cycles and forty cycles are recommended, the former where lighting is the chief load and the latter where motors predominate. With frequencies above forty, difficulty may arise in the parallel running of slow-speed, direct-coupled units having reciprocating engines, unless with the closest control through the revolution, and with favourable governing mechanism. The twenty-five-cycle rotary converter has the advantage of requiring little care in synchronising, and, being decidedly stable in running, can be wound with a series field to maintain the voltage constant, or even to increase it with the load. W. H. E.

457. *Condensers in Alternating Current Work.* **M. Leblanc.** (Écl. Électr. 25. pp. 264–268, Nov. 17, 1900. Paper read before the International Electrical Congress, at Paris.)—The author attempted as early as 1890 to split, by means of condensers, a simple alternating current into two currents in different phases capable of working a polyphase motor. Lately he has attempted, on somewhat similar lines, to make an alternating current motor which would have a power factor of unity. The want of good commercial condensers has hitherto prevented these machines being put on the market. He considers that Boucherot and Lombardi have shown how such condensers should be made. Great difficulties have been experienced from resonance effects with armoured cables. A machine in a Paris Central Station gave 4,000 volts safely when working on a resistance. When, however, it was connected to a concentric cable, the voltage being only 1,500, a torrent of sparks crossed the air-gap of the machine and set the insulating materials of the armature conductors on fire. This effect was due to resonance, and several other similar accidents are mentioned. He describes a case in which rotary converters introduced harmonics of about twelve times the normal frequency into the e.m.f. of the circuit owing to their commutators being divided into twelve segments. These harmonics cannot be detected by ordinary voltmeters; electrostatic instruments, for example, are quickly put out of action, as they serve merely as spark-gaps. Again, the self-inductance of hot wire instruments is very appreciable at high frequencies. A theoretical research is given of methods of suppressing danger from resonance due to harmonics in the e.m.f. wave. In conclusion, the author states that an alternating current network should have either a very small or a very large capacity. In the immediate future networks will be constructed which will be resonant for the frequency of the ordinary working current. This will necessitate the use of alternators compounded for constant voltage, so as to avoid a dangerous rise of pressure, and in addition the capacity of the network must be increased as the load increases. It will be therefore necessary to use a condenser with each motor, transformer, or converter. A. R.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

458. *Crewe Electricity Works.* (Electrician, 46. pp. 233–235, Dec. 7, 1900.)—This station is worked on the direct current system, with three-wire distribution. Plant of about 500 kw. capacity is installed, and full details of the engineering design are given in the article. It may be mentioned that both feeders and distributors are lead-covered single conductors, which are laid solid in wooden troughing. The network is fed at two points, by two single feeders, no feeder running to the third wire; these conductors have each a sectional area of 0·2 square inch. Five distributors are laid together in one trough; of these, two 0·2 square inch conductors are for private lighting, two 0·1 square inch for the public incandescent lighting, and one 0·2 square inch conductor acts as a middle wire common to both. All the distributors are brought back to the generating station. W. H. S.

459. *Sydney Tramways.* **A. C. F. Webb.** (Elect. Rev. 47. pp. 745–747, Nov. 9; and 790–792, Nov. 16, 1900.)—The line runs along George Street, the principal thoroughfare in Sydney; the power-house, however, is arranged so that plant may be installed to run the whole system of present steam trams electrically. The system is overhead trolley and direct current, with buffer batteries.

The *boiler-room* contains 14 multitubular boilers, 16 feet long by 7 feet in diameter, having 72 tubes 4 inches in diameter. The feed water is heated by Alvis hot-air economisers. The *engine-room* contains four 850-kw. sets, consisting of Allis compound horizontal engines coupled directly to General Electric multipolar generators. The engines have cylinders 26 and 48 inches by 48 inch stroke, and run at 100 r.p.m. The generators have twelve poles, the armatures being drum-wound in slots. They are provided with flywheels 20 feet in diameter, weighing 40 tons. The engines exhaust into Wheeler condensers. The batteries of accumulators consist of E.P.S. cells, 300 of K 23 type and 300 of K 9 type. The overhead line has centre-pole construction, Mannesmann steel poles being used, with iron brackets; the trolley wire is figure 8 section of 0·13 square inch area, and suspended by Billings and Spencer hangers.

The permanent way, which is double track, laid with 7-feet centres, consists of 83-lb. grooved rails laid upon concrete with a wood-block road bed; the joints are bonded with Edison-Brown plastic bonds. The feeder cables are Callender's make, 0·45 square inch section, and are laid underground in Callender-Webber casing. Return cables of the same section are laid between each track and connected to alternate rails on each side; the two cables are cross connected every 60 yards. These cables are coated with Stockholm tar.

The type of car chiefly employed is a combination bogie, carried on two four-wheeled bogies; the car is 36 feet long by 6 ft. 8 in. broad, and weighs 10 tons with equipment; its capacity is 48 passengers. The trucks are Brill and Peckham types.

Another line, the Rose-Bay line, is an extension of the Ocean Street cable line. It is only 1¼ miles in length, but 55 per cent. of the distance is composed of curves, and the gradients go up to 1 in 11. Two 150-kw. General Electric six-pole generators, running at 400 r.p.m., are driven by the cable engines at the Rushcutter Bay power-house by counter-shafting and belting. A battery has been erected of 240 R 9 type Chloride cells. Poles with side brackets are used for the overhead construction; these carry two overhead lines, one for down and the other for up cars. The feeder cables are of Callender's lock-coil type, laid direct under the footpath. The track is a single one, with three turn-outs; it is laid with 83-lb. rails, bonded with plastic bonds.

In North Sydney, over seven miles of line are now opened for traffic. Power is supplied from a main power-house at Ultimo by means of submarine feeders laid under the harbour. There are three battery stations—one at Ridge Street of R 9 Chloride cells, one at Spit Road of 215 K 19 E.P.S. cells and 20 R 9 Chloride cells, and one at Willoughby of 238 Chloride cells. A Tudor battery is under order for Ridge Street. At both the Spit Road and Willoughby feeder stations Parker boosters are installed, consisting of a motor, running at 950 r.p.m., driving a series wound generator giving 100 amperes at 50 volts. For the overhead line side pole construction is used for single track and span wires for double track lines.

The Middle Harbour line is laid with 90-lb. rails and 85-lb. guard rails on ironbark sleepers, laid on ballast. The Mosman's Bay and Willoughby lines are laid with 60-lb. Vignoles rails, bonded with plastic and with Chicago-type bonds. The Gore-Hell line has 88-lb. rails and plastic bonds.

The articles contain load curves and numerous illustrations. G. H. B.

460. *Hydro-electric Installation at Vizzola.* **A. Luraschi.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 139–171, Aug. 14, 1900.)—This scheme utilises the power developed by a fall of about 90 feet on the river Ticino. The power is mainly supplied to cotton factories, which utilise about 10,000 h.p., the total power available being about 18,000 h.p. The author first describes in some detail the engineering work in connection with the construction of dams, &c. Ten pipes, having an internal diameter of 6 ft. 8 in., are brought into the station, and supply ten turbines of 2,000 h.p. each; two other pipes of 3 feet internal diameter supply two smaller turbines of 220 h.p. each. The larger turbines, at 197 r.p.m., drive triphase generators; the smaller turbines drive continuous current generators at 300 r.p.m., in both cases direct connected. Seven three-phase generators, by the Schuckert Company, have been installed; they give 1,650 kw. at 11,000 volts, with a frequency of 50. The direct current dynamos, used for exciting the main generators and other purposes, give 145 kw. at 110 volts. The voltage of 11,000 was considered the most suitable in view of the fact that the installation is intended to supply power over a radius of about 25 kilometres. A list is given of some of the principal sub-stations which are placed in a large number of towns and villages. At these places, transformers of 200 kw. capacity are installed, reducing the pressure to 3,600 volts; and consumers receive their power at this pressure, and also at a pressure of 125 volts, in case they require it for lighting purposes. The more important consumers have, however, sub-stations on their own premises, where the pressure is reduced to 500 volts. The author concludes by examining various financial aspects of the problems involved in power transmission. The figures given are mainly borrowed from various publications, and cannot conveniently be reproduced in this Abstract. W. H. S.

461. *Electrical Plant in the Transvaal Mines.* **A. W. K. Peirce.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 496–500; Discussion, pp. 501–502, Aug. and Sept., 1900.)—The central mining region, the Witte Water Rand, is supplied with power from a 2,500 kw. three-phase plant, transmitting at 10,000 volts over a pole line 25 miles long. The plant is installed at one end of the district on account of the proximity of coal mines. Branch lines are taken off at intervals along the reef where required, the pressure being transformed down. The porcelain insulators, which are not of high-pressure type, have given trouble by cracking and sometimes exploding. Iron poles, arms, and pins are used, as wood is destroyed by ants. Another three-phase plant of 1,500 kw. in the Central Rand generates direct at 3,300 volts and transmits over five miles. In this case the power is used largely for pumping in the mines, and the high-pressure current is carried down the shaft, in some cases 1,500 feet. The cables are three-core rubber-insulated, lead-covered and armoured, and they give excellent results. The current is transformed and used to drive low-pressure induction motors, usually geared to three-throw pumps. There are several direct-current installations, but such motors are not so satisfactory, owing to the dirt and damp and to the want of intelligent operators. A fairly high-pressure (900 volts or so) was tried for direct-current motors, and also for induction motors, but breakdowns occurred in the insulation.

The principal problem of the immediate future is the application of hoists suitable for shafts of depths ranging to 8,000 feet. This could be done in stages of, say, 3,000 feet, to avoid excessive weight of rope. The hoisting speed usually specified is 3,000 feet per minute, and the load is about 6 tons. The shafts measure 5 ft. 6 in. by 6 ft., and two hoists would probably be used in each shaft. W. H. E.

462. *Power Plant of the Chicago and North-Western Railway Workshops.* (West. Electn. 27. pp. 297–299, Nov. 10, 1900.)—This plant supplies power for the repair shops of a large section of the railway. The boiler-room contains six Babcock boilers of 250 h.p. each, with Roney stokers, working at 150 lbs. per sq. inch. Coal is delivered by rail to conveyors, which deposit it in bins of 180 tons capacity. The engine-room contains two 250-h.p. vertical compound condensing engines, each coupled to two 75-kw. six-pole dynamos, and one 60-h.p. engine coupled to two 20-kw. dynamos for the night-load. The engines were made by the Ball Engine Company, the dynamos by the General Electric Company. The larger engines have cylinders 12 and 22 inches in diameter and 14 inches stroke, and run at 270 r.p.m. The engine-room also contains an air compressor and a hydraulic pump for driving riveters, &c., two fire pumps, and a Cookson feed-water heater. Electricity is distributed on the three-wire system at 230 and 115 volts. The power and lighting circuits are independent, and are supplied by various sets of feeders. Any dynamo can be coupled to either circuit by throw-over switches, and if necessary both circuits can be run in parallel. The motors vary from 1 to 95 h.p., and aggregate 700 h.p. The lighting circuit provides for 100 arc lamps and 2,000 10-c.p. glow lamps. Out of doors the feeders are overhead, and are calculated for a 10 per cent. drop at full load, which, however, rarely occurs. Indoors the wires are rubber-covered and are carried on insulators. To minimise the disturbance due to changing from steam to electric power, most of the motors drive the original line shafting by belt. The buildings cover 100 acres, and 2,000 men are employed. A. H. A.

463. *Electrical Lead-Mining Plant of St. Louis Smelting and Refining Co.* (Elect. World and Engineer, 36. pp. 723–724, Nov. 10, 1900.)—This article describes an electric power and lighting plant at the St. Louis Smelting and Refining Company's mines at Westoge, Mo. Electric hoists are used for raising the ore, electric power drives the crushers, pumps, concentrating jigs, and also the 20-ton locomotives used for handling the ore cars. The plant is noticeable for the use of a large battery of chloride accumulators, which gives 70 to 80 per cent. of the fluctuating load caused by starting a hoist or locomotive, and enables the lighting to be carried out from the power mains without flickering. The plant is worked at 250 volts. Ll. B. A.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

464. *Electric Traction on Railroads.* **K. v. Kándo.** (Zeitschr. Elecktrotechn., Wien, 18. pp. 636–639, Dec. 30, 1900. Address before the Society of Engineers and Architects in Buda-Pesth.)—The author contends that the alternate-current solution of this problem is the best. The question is

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

altogether different from the problem of providing power for tramways. The distances and the amount of power required are much greater; and the load factor is also very different. For instance, on three interurban tramways in the neighbourhood of Buda-Pesth the ratio of the maximum to the mean load on the power stations ranges between 1·7 to 1, and 2·9 to 1. On the other hand, on a line, 15 km. long, running from Buda-Pesth to Vacs, where there is a fairly heavy traffic, similar to that on a railway, the above-mentioned ratio becomes 7 to 1. Batteries can be applied to contribute towards the equalisation of the load on the generators; but alternate-current transformers can also bear considerable overloads of short duration, and cost far less. The firm of Ganz & Co. went fully into the question when they undertook the reconstruction of certain Italian lines on the border of the Adriatic Sea, which work is now nearing completion. It was then decided to use alternate current, the high-tension current being applied direct to the motors without the intervention of any transformers. Before granting the concession to construct the line from Burgdorf to Thun, the Swiss Government consulted Kapp, Weber, and S. P. Thompson, all of whom reported that high tension was suitable and desirable on the proposed line. Before presenting his report, Weber carried out experiments with a view to ascertaining the voltage dangerous to life; and he reported that under certain circumstances 100 volts have been known to be fatal, while on the other hand under altered conditions 3,000 volts do not necessarily constitute a fatal shock. The author considers that under present railway conditions any advantages derived from increasing the voltage beyond 3,000 or 5,000 volts are outweighed by the increased difficulties of insulating the motors, and of constructing high-tension apparatus generally. The great objection to the alternate current lies in the distrust felt for high-tension current, in that it is possible for it to be dangerous to life. A shock can only result through failure of insulation, and then only supposing the current to leak away through bodies which are bad conductors in themselves, or are connected to earth through bodies having high resistance. This being the case, it is merely necessary to completely surround all conductors carrying high-tension current at all places by a continuous metallic sheath, and on the cars this metallic sheath must be directly connected in several places with the truck, and so with the wheels and rails. The carriage roofs must also be similarly connected to the wheels. The only piece of apparatus requiring manipulation is the motor switch, and this must be enclosed in a cast-iron case, and by interlocking arrangements it should be impossible to open the case unless the current has been previously switched off. At the various stations, the current should always be switched off the line, unless a train is either about to arrive or depart; and various precautions of a similar nature are mentioned. A slightly different solution of the problem lies in reducing the pressure by means of transformers carried on the trains; but this is not to be regarded as a satisfactory solution, seeing that it increases the weight of the train, and so does away with one of the chief advantages of electric traction which lies in the fact that the weight of the motors is small. Transformers might easily increase the weight of the train by 10 or 20 per cent. W. H. S.

465. *Automobile Batteries.* **E. Sieg.** (Centralblatt f. Accumulatoren- u. Elemententk. 1. pp. 183–186, May 15, 1900.)—The general properties that an accumulator should possess in order that it may be suitable for traction work are considered. As a basis of calculation it is assumed that a vehicle for four persons, each of 75 kg., or 0·3 ton (German) has when loaded a total weight

W, whilst the motor weighs $W/10$, and the empty vehicle is 2/3 the weight of the passengers, battery, and motor, or—

$$W = 0{\cdot}3 + B + W/10 + 2/3\,(0{\cdot}3 + B + W/10),$$

which becomes—

$$W = 0{\cdot}6 + 2B. \qquad (1)$$

Assuming a motor efficiency of 70 per cent., and a speed of 18 km. an hour, or 5 m. per second on the level, with a traction coefficient of 25 kilos per ton, then the power E required is—

$$E = \frac{W \times 5 \times 25 \times 100 \times 736}{70 \times 75} = 1750W \text{ watts.}$$

If the vehicle is required for a three-hours' service, corresponding to about a run of 50 km., then the capacity C of the battery in watt-hours will be—

$$C = 3 \times 1750W = 5250W \qquad (2)$$

or—

$$C = 1000Ba \qquad (3)$$

where $a =$ the watt-hour capacity per kilo for a three-hours' discharge of the battery. Hence from (1), (2), and (3)—

$$B\,(a - 10{\cdot}5) = 3{\cdot}15 \qquad (4)$$

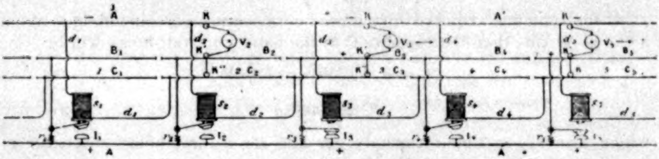
which gives the limiting value of a as 10·5 watt-hours, or with a mean pressure of 1·9 volts, 5·5 ampere-hours.

If B be 700 kg., then 8 ampere-hours per kilo of battery will be necessary. For stationary cells the capacity varies from 3–5 ampere-hours per kg. The author then considers the possible means of making automobile cells with the much greater specific weight-capacity demanded. W. W. H. G.

466. *Automatic Electric Carrier.* (Écl. Électr. 24. pp. 390–393, Sept. 8, 1900. From a paper read before the Société Scientifique et Industrielle de Marseille, May 17, 1900, by H. Dubs and L. Laffitte.)—H. Dubs and L. Laffitte have designed a high-speed automatic electric carrier, intended to take small parcels or letters. Their system comprises a double track carried on a viaduct, with motor-vehicles and control apparatus. The track is laid with rails weighing 12 kg. per metre to a 70-cm. gauge with conducting rails carried on insulators fixed to the sleepers. The track is protected from the weather by a continuous iron roof. The viaduct is about 3 m. above-ground. The vehicles are sheet-iron boxes with 2 or 4 axles and 60 cm. wheels. The motors are wound on the axles themselves, and when running at 2,200 r.p.m. give a speed of 250 km. per hour. Current is picked up by three shoes in duplicate in the front and at the back. The vehicles are 6 m. long, torpedo-shaped, and comprise a central compartment for goods and a compartment at each end for the automatic regulating apparatus. Gradual starting is effected by a centrifugal regulator, which cuts out resistance in the armature circuit as the speed increases. When current is cut off the regulator reinserts the resistance ready for starting. Stopping is effected automatically by brake blocks on each wheel, which are only held off when current is passing through a controlling solenoid. The line is divided into sections proportional to the headway between the vehicles. Current is supplied to the shoes KK′ by a continuous rail A′ and a sectional conductor $B_1, B_2, \ldots B_n$, which is itself fed from a fixed conductor A through interrupters $I_1, I_2 \ldots I_n$. A second sectional conductor $C_1, C_2 \ldots C_n$ is provided parallel with $B_1, B_2 \ldots B_n$. Each vehicle carries three shoes, K rubbing on A′, K′ on B and K″ on C, K′ and K″ being electri-

cally connected. When no vehicle is on the line, all the interrupters I_1, I_2 . . . I_n are closed and B_1, B_2 . . . B_n are connected to A. If a vehicle comes on to section 5, a current passes through A, I_5, B_5, K′, K″, C_5, d_4, s_4, d_4, A′ and opens the interrupter I_4, so that no vehicle can overtake the one on section 5. If the momentum of a vehicle V_2 has carried it from an active section 1 on to a dead section 2, the interrupter s_1 will be opened by current round s_1 through A, r_2, B_2, K′ K″, C_2, d_1, s_1, d_1, A′, and the vehicle will stop on section 2, the resistance r_2 being such as to allow sufficient current to pass to operate the interrupter, but not enough to hold off the brakes.

The above description assumes the use of continuous currents, but actually three-phase currents and asynchronous motors have been used, thereby securing almost constant speed as well as avoiding commutators and brushes, without unduly complicating the connections. The inventors calculate that the power required to move the vehicles at 250 km. per hour will be about 45 h.p. on the level and 60 h.p. on a 2 per cent. grade. They propose generating stations at distances of 40 to 50 km., the maximum safe voltage at the motors being 300 volts. E. H. C.-H.



REFERENCE.

467. *Electricity Applied to Mining.* **H. Bentham.** (Elect. Engin. 25. pp. 669–672, May 11; and 695–697, May 18, 1900. Paper read before the Manchester Society of Junior Electrical Engineers.)—This is a general description of the problems arising in coal-mining work, and gives details of methods in actual use applied to a particular case, and also gives a detailed estimate of comparison of first cost and working costs of steam and electric plants respectively, showing, after allowing 5 per cent. interest and 10 per cent. depreciation, a balance of £303 per annum in favour of electric working on a 1,000-h.p. plant. Ll. B. A.

TELEGRAPHY AND TELEPHONY.

468. *Woolley's Magneto-Electric Telegraph System.* (Elect. World and Engineer, 36. pp. 858–859, Dec. 1, 1900.)—This is an invention of L. G. Woolley for operating fire alarms, telegraphs, railroad semaphores, fog signals, &c. The transmitter consists of a magneto-generator whose armature is under constant spring tension. The tension is released by the operation of a common transmitting key. When the key is pressed and released each movement lets the armature fly through half a revolution, and it gives a current in each case of opposite polarity. The sudden stopping of the armature gives a current of high pressure. These currents being received on a polarised relay can be utilised for any of the purposes intended. The inventor has devised a field service telegraph worked with his transmitter instead of a battery; the receiver is in a light metal box strapped to the body; the relay armature oscillates and taps upon a diaphragm, and from this latter rubber tubes proceed to the ears. In fire alarm work the armature of the magneto-generator is operated and controlled by clockwork. The receiving relay at headquarters controls the mechanism of a mechanical gong on which the alarm is sounded, at the same time a record of the signalling box number is made on a tape run through a recording instrument, which is set in motion by secondary impulses. The lines are at regular intervals under test automatically, and should abnormal conditions occur the fact is made known by the sounding of a gong. E. O. W.

469. *Cable Speeds.* **J. E. Young.** (Electrician, 46. pp. 89–92, Nov. 9, 1900.)—Speed of signalling is determined primarily by the constants of the cable as affecting wave-propagation and wave-form. It is further limited by the degree of efficiency of curbing devices, or of similar apparatus used for the purpose of shaping the impulses. Finally, it depends upon the degree of sensitiveness of the receiving apparatus. By extending Kelvin's diffusion theory to include inductance and leakage, Heaviside has been able to investigate the general case of cable speeds. The writer points out certain differences of nomenclature existing between Heaviside and custom. Thus the letter K, which generally denotes electrostatic capacity, is used by Heaviside for the "leakage conductance," whilst his symbol for "static capacity" or "permittance" is S. Thus Heaviside's line-constants are $R =$ conductor resistance, $S =$ capacity, $I =$ inductance, and $K =$ leakance. The condition of the "distortionless circuit" is $L/R = S/K$, but in practice this is never attained. The electromagnetic time-constant is the ratio of henrys to ohms, *i.e.*, seconds. Approximately, it is the quantity which would determine the rate of the electromagnetic discharge, or "extra current," if there were no electrostatic capacity in the circuit. The usual electrostatic time-constant, the "KR" of commerce, is expressed in seconds, ranging from one to ten for submarine cables. It is the time governing the rate of the static discharge in the absence of counteraction by electromagnetic capacity or inductance. If the capacity were all at one cross-section of the cable and discharged through the resistance of the conductor, this latter "KR" would be the time in which the cable would lose 63·2 per cent. of its charge. The other electrostatic time-constant is the product of megohms and microfarads, and for well-insulated cables is generally of the order of minutes. It is the interval in which the cable loses 63·2 per cent. of its charge by leakage through its dielectric, were it not for the action of absorption. Heaviside shows that when the magnetic is one-third of the static time-constant the impulsive inductance balances the impulsive capacity, if we neglect distribution and leakage. Again, whilst the first static time-constant, RS, varies as the square of the length of the cable, the second static and the magnetic time-constants are independent of it, so long as I is the natural inductance, either of a land line or of the conductor and sheathing wires of an uncoiled cable. It appears likely that S varies with the frequency. In the case of siphon recorder signals, very little increase of speed is to be derived from any arrangement of isolated leaks. If, however, a cable is to be worked much below its maximum recorder speed, then one or more leaks may prove of value by discharging the line rapidly and by increasing the definition. In considering the method of reducing distortion by increasing the inductance, the author refers to the experiments of Breisig and of Pupin, and points out that whilst the interposition of inductance at a single position in the cable occasions wave reflections when the wave-length is less than that of the cable, its distribution at multiple points does so to a decreasing extent as the number of coils is increased up to a certain limit, beyond which there is no appreciable advantage. R. A.

470. *Magnetised Coherer.* **C. Tissot.** (Comptes Rendus, 130. pp. 1386–1388, May 21, 1900.)—The magnetised coherer [see Abstract No. 1617 (1900)] is used in connection with apparatus at Portzic lighthouse, and signals were exchanged with a battleship at a distance of 61 km. The author emphasises the advantage of desiccating the filings and the coherer tube, so that the electrodes and filings may always be bright. It is found of great value to be able to adjust the "critical tension" of the coherer contacts by means of the magnetic field. The resistance unmagnetised may be 500,000 ohms, but by magnetisation this can be brought down to between 1,000 and 2,000 ohms. In the present instance, for example, the relay refused to work when the coherer resistance was 3,000 ohms, but it worked excellently when this was adjusted by magnetisation to 1,500 ohms, *i.e.*, to the "critical" condition. R. A.

471. *Syntony in Wireless Telegraphy.* **A. Blondel.** (Comptes Rendus, 130. pp. 1383–1386, May 21, 1900.)—According to the experiments of Bjerkness and the theory of Poincaré, the oscillations at the emitter are so quickly damped that there is no possibility of establishing true resonance at the receiving station, so that methods of selection must be regarded as empirical. In 1898 Blondel deposited with the Académie a paper entitled "Perfectionnements à la télégraphie sans fil," in which is described a method of obtaining syntony, not between the oscillator and the receiver, but between two artificial frequencies, using a selective telephone. Instead of the Morse apparatus and relay generally adopted, the suggestion was to employ a vacuum tube in series with a telephone and a battery, the normal potential difference being just too low to permit a discharge to traverse the tube, but sufficient to produce a current at each impulse from the oscillator. The telephone responds to each emission from the sending station, and the tone is determined by the number of discharges per second from the emitter. At short distances the vacuum tube is unnecessary. By varying the frequency at the emitter it is possible to differentiate between various stations, and by the employment of appropriate telephones a selective system is obtained. A Geissler tube should be used, with broad electrodes almost in contact.

A tuning device, consisting of a condenser and inductive resistance, may be applied at the receiving end, the best values for which, for a given frequency, can be easily calculated by the "pendulum" formula. R. A.

472. *Vienna State Telephone Exchanges.* **H. Dreisbach.** (Elektrotechn. Zeitschr. 21. pp. 864–869, Oct. 18; and 883–887, Oct. 25, 1900.)—In these papers are described the two new exchanges of the Vienna State telephone system. They are designed for 12,000 subscribers with complete metallic circuits, using the Western Electric Company's multiple switch with incandescent-lamp indicators. The cost of the buildings was 755,000 M. and 845,000 M. respectively; of the technical arrangements at the same two buildings 1,090,000 M. and 508,000 M. respectively, and at a secondary exchange-office, 60,000 M.; of the connections between the existing network and the exchanges, 94,000 M., for the cement conduits (Hultmann's system, see Elektrotechn. Zeitschr. 1898, No. 7), and 821,000 M. for the cables. The papers are illustrated by a large number of drawings and photographs giving details of the buildings, instruments, and conduits, together with diagrams of connections. C. K. F.

473. *Magneto-Telephone Signals.* **N. H. Holland.** (Elect. World and Engineer, 36. pp. 782–785, Nov. 17, 1900.)—After giving some historical notes, the author goes on to describe the following as a very promising form: Between the two horseshoe magnets a coil is supported by a strong flat spring. The coil has a handle which permits the coil to be pulled to one side and then allowed to swing back, whereby currents are generated. An armature of the Siemens type rotated between the prongs of three or four horseshoe magnets is the generator that has been found best suited to meet all the requirements of telephone service. A standard three-magnet generator, when carefully made, will have an output of about 5 watts at a pressure of 80 volts and an armature speed of about 1,500 r.p.m. In Gray's patent of 1884 a generator is shown in which the fields are composed of electromagnets energised by the local battery. A number of different styles of polarised bells have been used, but nothing has yet equalled that form in which the armature is centrally pivoted in front of the electromagnets. Methods suggested for using a local battery for ringing polarised bells by means of an induction coil and vibrator have met with but little success. J. E. K.

474. *Wireless Telephony.* **W. H. Preece.** (Elect. Rev. 47. pp. 484–485; Discussion, pp. 485–486, Sept. 21, 1900. Paper read before the British Association.)—The first experiments were made in February, 1894, across Loch Ness, using two parallel wires, earthed at each end, one on each side of the lake. When the length of each wire was 4 miles, it was found possible to exchange speech across the Loch, at an average distance of 1·3 miles. In 1899 it was proved by experiment at the Menai Straits that the maximum telephonic effect is produced, other things being the same, when the parallel wires are terminated by "earth" plates in the sea itself. A wire 750 yards in length, parallel to another 3½ miles in length, with "earth" plates in the sea, enabled telephonic speech to be maintained across a distance of 2·8 miles. Similarly speech was transmitted by Gavey between Rathlin Island and the mainland of Ireland.

Discussion.—**O. Lodge** said he always held that conduction between the opposed circuits was a more important factor than the induction between the wires, although the two helped one another and went in the same direction. In some cases it might be possible that induction was the more powerful. With induction stronger currents could be developed, tuning was better and resonance more effective than with conduction. One reason why the telephone and high-frequency currents are so efficient arises from the fact that such currents do not spread in three directions. The conductivity of the earth is sufficient to keep high-frequency currents near the surface, so that they are more or less restricted to two dimensions. **J. West** pointed out that as regards these systems as applied to signalling between two ships at sea, he found that the parallelism of the induction wires was of great importance; ships at right angles to one another cannot transmit signals by this method. **W. H. Preece** emphasised the need for eliminating self-induction from the circuits, and in general to make the impulse as abrupt in rise of potential as possible. R. A.

REFERENCES.

475. *Telephone System at Pittsburg.* **K. B. Miller.** (Elect. World and Engineer, 36. pp. 671–675, Nov. 3, 1900.)—Description of independent exchange with switchboard on Kellogg central battery system, using two contacts on the plug and two strands in the cord. J. E. K.

476. *The Telegraphone.* **V. Poulsen.** (Electrician, 46. pp. 208–210, Nov. 10, 1900.)—A description of the instrument referred to in Abstract No. 1973 (1900).

477. *Wireless Telegraphy.* **A. Blondel** and **G. Ferrié.** (Écl. Électr. 24. pp. 471–475, Sept. 22; and 491–499, Sept. 29, 1900. Paper read before the International Electrical Congress at Paris. Abstract in the Electrician, Oct. 26, 1900.)—This is a review of the history of wireless telegraphy, both as regards apparatus, theory, and results. R. A.